Teaching and Learning Mathematics and Science in a Second or Third Language

by

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I am the author of the thesis entitled

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Abstract

Teaching and learning in a second or a third language is not an easy task. Literatures have indicated that teachers and students involved have to struggle in order to cope with a language policy that requires them to teach or learn in an unfamiliar language. There is no doubt that in the learning process, language is the most powerful tool to deliver knowledge and skills. It becomes more difficult for learning to occur effectively if the language of instruction becomes a barrier to the learners.

This study focuses on the teaching and learning of mathematics and science in English in Malaysia, where English is a second or a third language to both teachers and students. The main aim of this research is to investigate how languages are used in mathematics and science classes taught in a second or third language, and to understand how these are supported with multimodal resources. This study employed qualitative methods, involving a multiple case study and interpretive research paradigm. A number of approaches to data collection were used including classroom observations and video recording. Data were gathered mainly from classroom video-recording, supported by video-stimulated recall interviews of teachers and students, and classroom observation. Transana, an analysis software tool is used to analyse the data through a coding procedure.

One of the main findings coming out of the study concerns the usage of English. As the language of instruction, English was only used in a formal form with the support of provided resources. However, Malay and a mixture of languages supplemented the function of English in situations when English proved inadequate for meaning generation.

The next finding shows that, in most cases, English was the main language used for content related talk in which English resources such as textbook and written notes were available for the teachers. Malay on the other hand, was used for other types of talk, such as organisational, disciplinary and informal talk, as well as teacher-students interactions during group work discussion.
Another important finding of this research is the teachers’ and students’ choice of languages. Their choice of languages were influenced by several factors, but the major influence seemed to be the teachers’ language level where language shifting in the classroom was highly dependent on the teachers’ language resources needed to express complex meanings.

Finally, as the main contribution to the field, it is found that a range of modes such as gesture, visual and mathematical representations, artefacts and embodied experiences, as well as natural language, seemed to play a crucial role in the meaning making and translating process in bilingual mathematics and science classes.

This research has demonstrated in some detail the pedagogical implications of Malaysia’s language policy, and by extension has highlighted some significant issues around the implementation of a policy of bilingual teaching in mathematics and science, more generally.
CHAPTER 1

Introducing the Study

1.1 Introduction

This chapter contextualizes the problem this study intends to address. First, a statement of the problem is discussed. Then, the context of the study is presented. Finally, it presents the background of the study which discusses briefly the education context in Malaysia, and the researcher’s background and perspectives in relation to the proposed study.

The problem that this study addresses is the usage of languages in the teaching and learning of mathematics and science in a second or third language. Language plays a crucial role in mathematics and science classrooms, as in other subjects. Particularly, in mathematics and science classrooms that use a second or third language as the language of instruction, the language issue is seen as complicated. In first language mathematics and science classrooms, teachers and learners are required to learn the academic language of mathematics and science, which is different from everyday language. Learners in a second or third language mathematics and science classrooms on the other hand, need to deal with both the academic language of the subject and the language of instruction.

Importantly, in learning mathematics and science, learners are also expected to have the ability to understand the multiple modes of representation that are used extensively to convey meaning in mathematics and science. Contemporary research studies establish that focus needs to be given to the various aspect of representation in mathematics and science as a crucially important element of learning. A number of research studies have also identified that the representational aspect is a key difficulty in learning mathematics and science, especially to integrate and coordinate the many types and forms of representations.
Given such a context, this proposed study intends to investigate the teaching and learning of mathematics and science in a second or third language, particularly focusing on the aspects discussed above. This study examines strategies that are employed by both teachers and students in consideration of dealing with these multidimensional challenges, in their second or third language mathematics and science classrooms. In spite of the fact that many research studies have discussed various problems of teaching and learning mathematics and science in bi/multilingual settings, too little attention has been given so far to the challenges of dealing with multiple modes of representations in a second or third language.

1.2 Context of the Study

Throughout the world, mathematics and science are learned and taught in situations of language diversity. In many countries, language other than students’ and teachers’ first language is used as a medium of instruction in mathematics and science classrooms, due to various factors such as colonisation, migration, and globalisation.

For example, Rollnick (2000) defined two broad categories of second language learners of science. The first category is for learners who have come to a country, and learned partly or fully in another language, whereas the second category is the learners of a multilingual country which use a former colonial language as a medium of instruction at school. The ICMI (International Commission on Mathematical Instruction) Study 21 Discussion Document (Committee, December 2009) identified a number of different settings of societies around the world that learn mathematics in a language that is different from their first language. It includes societies that have more than one official language where one of them has a higher status than others, societies in which a foreign language is taught through subjects like mathematics, and societies where the language of instruction changes across primary, secondary, and tertiary levels.

With these linguistically diverse contexts of teaching and learning mathematics and science, one of the associated issues concerns the importance of language. Learning occurs in complex linguistic environments, and in these contexts particularly, complexity derives from the multiple language backgrounds, mathematical and scientific languages, and the semiotic systems that are always present. Teachers and
learners routinely find ways to discuss and learn mathematics and science, regardless of how they feel in terms of the language they use to learn.

It is also common in many countries that a global language, such as English, is associated with high status jobs or access to the dominant class (Committee, December 2009). This situation has led to pressure within the education systems to use the global language in teaching and learning. Learners then are required to switch from their main language to the global language at some point in their education. However, many learners may be ill-prepared to engage in such change.

This study sits within this globalised context to look at this issue of the teaching and learning of mathematics and science in a language that is different from the learners’ first language. It intends to understand how teachers and students discuss and learn mathematics and science in such a context in terms of the language being used. As the study was done in Malaysia, which is a multilingual and multiethnic country in which mathematics and science were taught in English, the diverse linguistic backgrounds of the teachers and the students allowed a valuable insight into the ways in which they use language in their mathematics and science classrooms.

1.3 Background of the Study

This following section discusses briefly the medium of instruction policy scenario in Malaysia, as well as the researchers’ background and perspective as the background of this study.

1.3.1 The Medium of Instruction Policy in Malaysia

Since its independence in 1957, Malaysia has gone through tremendous changes in the medium of instruction policy. The post-independence period led to a shift from English, the language of the colonial masters, to Malay language, the language of the dominant ethnic group1. In the beginning of 1957, Malay language was made a compulsory language in all government aided primary and secondary schools. Then,

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1 The focus on Malay language and English does not mean that there are no other languages. Malaysia is a multiethnic nation where other languages such as Mandarin, Tamil and a host of other minority languages, guaranteed equal opportunity under Article 152 of the constitution (as cited in Gill, 2005)
one year after independence, national secondary schools which use the Malay language as the medium of instruction, started to operate. From 1970 onwards, there was a gradual shift in the medium of instruction in the English medium schools and, by 1982, the Malay language became the sole language of instruction. In 1983, all public universities began to use Malay for all teaching purposes (Puteh, 2006).

For a period of almost thirty years, Malay language has successfully functioned as the language of education. Enormous effort and resources were spent in cultivating and establishing the Malay language, especially to enable the language to cope with the demands of the field of science and technology (Gill, 2006). English on the other hand, retained its official language status in Malaysia for only ten years after independence. After that period, English was relegated to a second language, and from a medium of instruction to a school subject (Puteh, 2006).

However, in the early 1990s, English was reinstated as the medium of instruction in higher education especially in fields of engineering, science and medicine. The change of policy has resulted in a bifurcation of the policy in higher education, whereby public institutions of higher education retained the Malay language as a medium of instruction. At the same time, private institutions of higher education were given the freedom to use English as a medium of instruction. These changes were then followed by another decision made by the government in 1993, which was to allow the use of English in science, engineering, and medical courses in universities and college. Since 1996, with the introduction of the Education Act 1996 and the Private Higher Education Institutions Act 1996, the use of English as a medium of instruction for technical areas in post-secondary courses and the latter has been approved. The move from Malay to English was considered as essential for the economic and technological development of the nation.

The Teaching and Learning of Mathematics and Science in English (ETeMS)

In January 2003, another major change in the Malaysian education system was introduced, which was the re-adopting of English language as a medium of instruction for mathematics and science in national schools. The change was implemented in a staggered fashion, beginning from Standard 1 in primary schools, and Form 1, Form 4
and Form 6 in secondary schools. The decision to take this move was underpinned by several reasons, including the ability to compete in the era of globalisation and the knowledge and information explosion in science and technology with English as the most influential lingua franca (Yassin, Marsh, Tek, & Ying, 2009). The advances in science and technology demand new skills and abilities and this has impacted on the teaching and learning process (Idris, Cheong, Nor, Razak, & Saad, 2007).

Since its implementation, many debates have been raised among the general public, parents, political parties and even teachers on the effectiveness of the policy. Many people considered this change in the language of instruction as a formidable challenge. Mathematics and science teachers faced several challenges, having to cope with the double demand of transmitting content as well as language. It poses particular challenges not only for teachers who have been trained in the Malay medium but also for those trained in English as their professional experience has largely involved them in the use of Malay language as the medium of instruction (How, Yan, Wan, & Kaliappan, 2005). On the other hand, students with low proficiency in English also faced the double challenge of learning the subject and learning the new language of instruction.

Many programs such as training, workshops, pre-service and in-service courses have been conducted as well as CD-ROM-based courseware developed by the Education Ministry to improve teachers’ English proficiency and to assist with the teaching of mathematics and science in English.

The Abolishment of ETeMS

Six years after implementing ETeMS, the Government of Malaysia announced another massive change in the education system. In July 2009, the cabinet approved the Ministry of Education’s proposal to abolish ETeMS, reverting to Malay language and vernacular languages in phases effective from 2012. The move would see national schools (primary level) teaching mathematics and science in Malay language, while Chinese and Tamil schools would employ their respective vernacular language. Secondary schools throughout the country will use Malay language as the medium of instruction.
This new policy would be implemented in stages at the beginning of 2012, starting with Standard 1 and Standard 4 in primary schools and Form 1 and Form 4 in secondary schools. Matriculation, Form 6 and university levels however, would not be affected with this change. To ensure that the implementation would not affect the performance of students currently learning mathematics and science in English, the teaching and examinations for these two subjects will be done in dual language until the last cohort of ETeMS ends in 2014.

Based on much research and observation, the government declared that the ETeMS policy could not be implemented to achieve its desired goal. Studies have found that only a small percentage of teachers were fully using English in the teaching of the two subjects, as was intended. Meanwhile, the primary school evaluation test results had shown a decline. Furthermore, the disparity in results between urban and rural schools was widening when ETeMS was being implemented. A Trends Report also showed Malaysian Students’ position went down from the 20th place to 21 since the implementation of ETeMS ("PPSMI: 'Declining scores prompted policy reversal' ", 2009). The government also admitted that students faced difficulties in coping with English as the language of instruction, and their ability to learn the subjects had dropped.

Rather than being used as a language of instruction, the English language will continue to be taught as a compulsory subject. It will be enhanced at the school level by recruiting an additional fourteen thousand English teachers. The duration of English lessons for all levels of schooling will be increased, and interactive computer lessons will be employed.

As well as its symbolic and embodied aspects languages are framed within, and encapsulate, the ways in which the world can be understood, spoken about and behaved within. As such, language and culture are inextricably intertwined. Unequally empowered ways of thinking within communities interrelate in ways that make the formulation of national culture and identity intensely political. Processes of globalisation, colonisation and migration add new and powerful dimensions to this process and complicate the ways languages and languages education is understood and implemented (Pennycook, 1998). The increasing importance of English as a lingua franca and international language, particularly for purposes of communication,
trade and science and mathematics dissemination, adds further dimensions to this process (Crystal, 1997). In Malaysia, this interrelation has been of particular significance as British Colonisation between 1786 and 1942 has at various times made English language education both essential and something to be fought against. Historically it can be seen that English language education has been, at different times, embraced and rejected, in part as a product of this relationship.

The insight of post-colonial literatures is that the relationship between language and identity is not merely superficial. Resistance to colonialism, in Malaysia as elsewhere, suggests that people need to be able to work from outside of the structures inflicted upon it within language thinking and structures of the colonisers’ language (Pennycook, 2000).

1.3.2 Researcher’s Background and Perspective

In order to illustrate the personal background and perspective of the researcher, this section will be presented from the first person point of view.

My teaching background started when I was appointed as a tutor at the University of Malaya, Kuala Lumpur, in 1996. Since then, I have been teaching various linguistics and Malay language courses for undergraduate level, at two other public universities, namely the Islamic International University of Malaysia, and Sultan Idris Education University, the university where I am currently attached.

My experience of teaching linguistics and Malay language courses for almost fourteen years has motivated me to investigate the current policy, which is the teaching of mathematics and science in English, in depth. Based on a considerable number of studies, many challenges have been identified in implementing such a policy for students or teachers. Research has revealed that one of the biggest obstacles for this policy to succeed is the English language proficiency of both among teachers and learners. At the same time, many studies have been carried out to investigate teacher professional development, as well as the achievement levels and support that has been given to successfully implementing the policy.
As yet, few studies have been found that give specific attention to problems faced by learners, or specific techniques for supporting groups of learners who have difficulty in using English to learn. This seems to be a gap in this area of investigation that needs to be filled if we are to get the whole picture of the situation. More specifically, the crucial aspects of learning mathematics and science that required students to deal with various forms of languages has not been fully investigated. I believe that an understanding of the issues associated with teaching and learning mathematics and science in a second or third language issue can only increase if we try to look through the lens of the teachers and learners. A comprehensive study is needed of the challenges of using different types and forms of language in mathematics and science, if we are to understand the challenges of learning those subjects in a second or third language.

With the decision to revert the medium of instruction for mathematics and science back to Malay language in July 2009, much discussion occurred between my supervisors and I regarding the impact of this sudden policy change on my study, which was initially intended to investigate language use in the context of the ETeMS policy. By that stage however, my literature review had shown a range of global issues in bilingual teaching especially related to mathematics and science, and I had become interested in the use of representations in mathematics and science teaching and learning, a contemporary perspective receiving a lot of attention in the research literature. The fact that the policy did not begin to operate until 2012 provided a brief window of opportunity to collect data in Malaysia that related to this global issue.

In my view, this topic is relevant in both the global and national context. It could be well justified on the basis of the literature review in terms of its relevance to the global setting of bilingual education, and its innovative nature in bringing a more complex view of language into play. Ultimately, this research provides insight into the Malaysian experiment in teaching and learning mathematics and science in English.
CHAPTER 2
Reviewing the literature

This chapter reviews the relevant literature on teaching and learning in a second or third language generally and specifically focuses on teaching and learning issues in mathematics and science. Drawing from the literature on teaching and learning in other than first language from all over the world, this chapter consists of two main sections. The first section outlines the scope of second or third language learning globally. In this section, first the contexts and reasons of bilingual education are discussed. Next, a number of models of bilingual education that existed throughout the world are presented. Then, the experience of teaching and learning in a second or third language is discussed. Finally, the experience of Malaysia in regards to the teaching and learning of mathematics and science in English is presented.

The second section deals with literatures related to the teaching and learning issues in mathematics and science. Initially, research studies on classroom talk in general and discourses in mathematics and science classrooms are discussed, followed by a discussion around the importance of multimodality in mathematics and science. Second or third language learning in mathematics and science are then discussed which includes the issue of multimodal representations in second or third language mathematics and science classrooms. The final section introduces issues concerning discourse and semiotics in a broader perspective, and lastly, the perspective of this research is presented.

2.1 Second or Third Language Learning

In many parts of the world, education that involves the use of two or more languages constitutes the normal everyday experience. Many more children throughout the world have been, and continue to be, educated via a second or a later acquired language, at least for some portion of their formal education, than those who are educated exclusively via first language (Alatis & Tan, 2001, p. 332). This type of education, with varieties of models or programs, is considered as bilingual education.
Baker (2006) states that sometimes the term bilingual education is used to refer to the education of students who are already speakers of two languages, and at other times to the education of those who are studying additional languages. Garcia (2009, p. 6) contends that bilingual education is different from traditional language education programs that teach a second or a foreign language, whereas bilingual education programs teach content through an additional language other than the children’s home language.

Bilingual education takes many different forms, and increasingly, in the complexity of the modern world, includes forms where two or more languages are used together in complex combinations (Garcia, 2009, p. 9). This argument is supported by Baker’s (2006) definition of bilingual education which he describes as a “simplistic label for a complex phenomenon” (p. 213). He asserts that two different situations exist under the umbrella term of bilingual education: education that uses and promotes two languages and relatively monolingual education for language minority children.

Garcia (2009) states that the phenomenon of using two languages in education has long been practised, since 4,000 to 5,000 years ago in Mesopotamia until today in the 21st century, throughout the world with a variety of contexts and purposes. Since the end of World War II, political, economic, ideological and educational events have demanded a more complex use of language. Most ex-colonial countries still apply the language of the coloniser and it is not unusual for such countries to continue the colonial language as their official language, for instance in many African countries and in India (Hamers & Blanc, 1989).

Migration due to reasons such as war, consequences of revolutions, decolonisation, and the movement of labour from undeveloped regions to highly industrialised countries are among the reasons for bilingual education (Hamers & Blanc, 1989). At the same time, minority ethnic groups have become conscious of their ethnic identity and have mobilised around language as a symbol, which has contributed to the need for bilingual education. Factors such as the expansion and democratisation of education throughout the world, linguistic heterogeneity of a country or region, specific social or religious attitudes and desire to promote national identity, have encouraged the implementation of bilingual education (Garcia, 2009; Hamers & Blanc).
Ruiz (cited in Garcia, 2009) has taken a language orientation in explicating the diverse aim of bilingual education, whether language is considered as a problem, a right or a resource. From the end of World War II until the early 1970s, language was seen as a problem. In some cases especially after World War I and II, bilingual education had become an alternative for a nation whose language turns out to be the minority language, such as the Latvian language for the Latvians in the former Soviet Union. Through bilingual education, especially transitional bilingual education, children were given the opportunity to use their own language during their early grades, and move to the majority or colonial language only when they had gained their fluency in the former language.

From the 1970s to 1980s, language was perceived as a right. The role of socio-historical processes in shaping particular forms of bilingual education, and in particular the role of class, ethnicity, race, language, and gender in such shaping, was given increased attention (Skutnabb-Kangas & Phillipson, 1994; Tollefson, 1991, 2002; Wiley, 1996, 1999) as cited in Garcia (2009, p. 15). When language minorities started to claim their language rights, they started to develop bilingual education programs that supported the revitalization of their languages.

Lastly, in the third stage (mid-1980s to the present), language diversity is seen as a resource. Bilingual education has been increasingly relevant to support language differences and the dominance of languages other than English such as Chinese, Spanish and Arabic. Phenomena such as globalization, the growth of Non-Governmental Organizations and advances in technology have increased the importance of bilingual education.

The following section will review different types of bilingual education as an overview of models of bilingual education around the world.

### 2.1.1 Models of Bilingual Education

Many researchers have outlined the diverse models or types of programs of bilingual education that exist throughout the world. Mackey (1970) has provided an elaborate and highly detailed classification of bilingual education. He distinguished 90 different
patterns of bilingual schooling with consideration of the purpose of the language, whether as the languages of the home, the curriculum, or the community in which the school is located, and the international and regional status of the language (Baker, 2006).

Most typologies of bilingual education incorporate broad goals including contextual and structural characteristics (Baker, 2006; Baker & Prys Jones, 1998; Brisk, 2006; Fishman & Lovas, 1970; Garcia, 1997; Skutnabb-Kangas, 1981; Skutnabb-Kangas & Garcia, 1995; Spolsky, 1978). A different approach to categorizing types of bilingual education is to examine the aims of such education. Edwards (1984) states that there are two dominant models in bilingual education, which are Transitional Bilingual Education and Maintenance or Enrichment Bilingual Education. Each model promotes different goals, where the first one aims to focus on fluency in the majority language, while the second model tries to maintain students’ proficiency in both minority and majority languages. Examples of Transitional Bilingual Education are to be found in United States of America (USA) and Europe, where the goal is to ensure minority children are educated in the majority language. Maintenance or Enrichment Bilingual Education are to be found in Canada and Wales, where the children are given the opportunity to use both languages at schools and become fully bilingual (Baker, 1988).

Baker (2006) in his book *Foundation of Bilingual Education and Bilingualism* portrayed ten different types of bilingual education. He divided the ten types into three groups: monolingual forms of education for bilinguals, weak forms and strong forms of bilingual education as shown in Table 2.1. Monolingual forms of education for bilinguals are programs offered for language minority children mainly aimed for assimilation and also for apartheid. Weak forms of bilingual education are types of program for both language minority and language majority children as a way for assimilation, limited enrichment and detachment, while the strong forms of bilingual education programs are offered to both language minority and language majority children with the aim to achieve bilingualism and biliteracy.
### TABLE 2.1 Typology of Bilingual Education According to Baker

<table>
<thead>
<tr>
<th>MONOLINGUAL FORMS OF EDUCATION FOR BILINGUALS</th>
<th>Language of the Classroom</th>
<th>Aim in language outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of program</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Mainstreaming/Submersion</td>
<td>Majority Language</td>
<td>Monolingualism</td>
</tr>
<tr>
<td>2. Mainstreaming/Submersion With withdrawal classes sheltered English/ content-based ESL</td>
<td>Majority Language</td>
<td>Monolingualism</td>
</tr>
<tr>
<td>3. Segregationist</td>
<td>Minority Language</td>
<td>Monolingualism</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WEAK FORMS OF BILINGUAL EDUCATION FOR BILINGUALS</th>
<th>Language of the Classroom</th>
<th>Aim in language outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of program</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Transitional</td>
<td>Moves from minority to majority language</td>
<td>Relative monolingualism</td>
</tr>
<tr>
<td>5. Mainstream with Foreign Language teaching</td>
<td>Majority language with L2/FL lessons</td>
<td>Limited bilingualism</td>
</tr>
<tr>
<td>6. Separatist</td>
<td>Minority language (out of choice)</td>
<td>Limited bilingualism</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STRONG FORMS OF BILINGUAL EDUCATION FOR BILINGUALISM AND BILITERACY</th>
<th>Language of the Classroom</th>
<th>Aim in language outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of program</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Immersion</td>
<td>Bilingual with initial emphasis on L2</td>
<td>Bilingualism and Biliteracy</td>
</tr>
<tr>
<td>8. Maintenance/Heritage Language</td>
<td>Bilingual with emphasis on L2</td>
<td>Bilingualism and Biliteracy</td>
</tr>
<tr>
<td>9. Two Way / Dual Language</td>
<td>Minority and majority</td>
<td>Bilingualism and Biliteracy</td>
</tr>
<tr>
<td>10. Mainstream Bilingual</td>
<td>Two majority languages</td>
<td>Bilingualism and Pluralism</td>
</tr>
</tbody>
</table>

Key:  
L2 = Second language  
FL = Foreign language

(Baker, 2006, pp. 215-216)
‘Monolingual forms of education for bilinguals’ comprise three different programs for language minority children, with the aim of monolingualism in language outcome. The first program is Mainstreaming or Submersion Education where language minority students are placed in mainstream schools together with the fluent speakers of the majority language, and will be taught in the majority language. In this program, only the majority language is expected to be used by the teachers and the students in the classroom. The native language has not been given any support since the main aim of this program is to assimilate the language minority speakers especially for the immigrants and indigenous language minorities. Schools are a perfect place to create common social, political and economic ideals. Baker’s (2006, p. 216) analogy of this program is “a language minority student thrown into the deep end and expected to learn to swim as quickly as possible without the help of floats or swimming lessons”. Many criticisms have been made of this type of education.

Valdes’ (1998) study shows that higher-order thinking such as questioning and critical thinking becomes impossible for students as a result of their minimal proficiency in English. In another study (2001), she discovered that such programs, “can deny access to the language and knowledge that could empower immigrant children” (p.217). Besides language problems, students face difficulties with social and emotional adjustment as well. Mainstreaming or Submersion Education has the effect of not only denying the students’ language but their self esteem, relationships, roots and sometime race (Baker, 2006). Skutnabb-Kangas (1981, 2000) argued that learning through an undeveloped language in mainstreaming causes stress since the students need to take in information from different curriculum areas and learn a language simultaneously.

Mainstreaming or Submersion with pull-out classes is the second type of program under the monolingual forms of education for bilinguals. Withdrawal classes or pull-out classes are provided for minority children to enable them to compete in mainstream schooling. In this program, the minority students receive English language learning provision, besides helping them to build self-esteem. However, drawbacks of such programs include that students may lag on curriculum content and they may be seen as ‘remedial’, ‘disabled’ or ‘backward in English’ by peers. There
are several types of pull-out classes such as Sheltered English or Sheltered Content Instruction in the United States (US) and Sheltered Content Teaching.

The third type of education is Segregation Education which is meant for minority language speakers who have been denied access to majority language speakers’ schools or programs. Apartheid is one of the targets of Segregation Education. In this case, the ruling elite prescribes education solely in the minority language to maintain subservience and segregation (Baker, 2006, p. 221).

The Weak Form of Bilingual Education for Bilinguals is a type of program which promotes relative monolingualism and limited bilingualism. Transitional Bilingual Education is one program that has been frequently implemented in the USA. The difference between transitional educational and submersion education is the permission given to the students to temporarily use their first language until they become proficient in the majority language. Two major types of Transitional Bilingual Education are “early exit” and “late exit”. Examples of the differences between these types of program are as follows: in “early exit”, the students are given two years maximum help using their mother tongue while in “late exit”, around 40 percent of classroom teaching in the mother tongue are allowed until the 6th grade. Programs for older students who have received education through their native language, immigrated, and require a transition to mainstream classes are also provided.

Another type of program is Mainstream Education (With Foreign Language Teaching) which is a program for majority language speaking students whose parents are English speaking monolinguals to learn second language at school. The second language, such as Arabic, French, German, Mandarin or Spanish, is taught as a subject for half an hour per day. Nevertheless, this type of education rarely produces functional bilingual children. Most of the students acquired a very limited knowledge of the second language due to a lack of motivation and a low demand for such language.

Finally, under the weak forms of bilingual education for bilinguals is Separatist Education, with the aims of minority language monolingualism and monoculturalism. It is an effort of the minority language speakers to protect their language from being over-run by the language majority, or for political, religious or cultural reasons.
The last type of bilingual education is The Strong Forms of Bilingual Education for Bilingualism and Biliteracy which have bilingualism, biliteracy and biculturalism as intended outcomes. Four types of program are included under these strong forms of bilingual education: Immersion, Maintenance or Heritage Language, Two Way or Dual Language, and Mainstream Bilingual.

Immersion Bilingual Education began in the 1960s from a Canadian educational experiment especially the St Lambert Experiment in 1965. It started from the effort of a concerned group of English-speaking parents in St Lamberts towards the growing importance of French as the main working language of Quebec and increasing dissatisfaction with the linguistic barriers between English and French Canadians. They succeeded in getting the school district to set up an experimental kindergarten immersion class in September 1965. The aims were for students to become competent in speaking, reading and writing French, reach normal achievement levels throughout the curriculum including the English language, and appreciate the traditions and culture of French speaking Canadians as well as English speaking Canadians. The St Lambert experiment was a success, and since then immersion bilingual education has spread rapidly in Canada and parts of Europe.

Immersion Education is a concept used with various programs throughout the world. The age of students and the amount of time spent in the program determined the specific program being implemented. The success of these immersion education programs depend on the features of the program, such as whether it involves two prestigious majority languages, or it is an optional program, with the students allowed to use their home language for up to one and a half years for classroom communication, and the teachers are competent bilinguals.

The next type of strong bilingual education is Maintenance or Heritage Language Bilingual Education, an education that allows minority students to use their native language as a medium of instruction at school with the aim of full bilingualism. At the same time, the majority language is developed together with the native language. For instance, education through or partly through the medium of Navajo and Spanish in the US, Hawaiian indigenous immersion, community and heritage languages in Australia and Wales, and immersion education for Māori in New Zealand are part of Maintenance Education (Baker, 2006, pp. 238-239).
Heritage or Maintenance Language Education can be found in schools and community based language initiatives in its more inclusive usage. It was reported that in the early 1980s, 6553 heritage language schools which used 145 different mother tongues of various communities were located in the USA (Fishman, 2006). Most of the schools used the native language as a medium of instruction besides having a subject of the language itself, and the schools received support from foreign governments and religious institutions. Among the communities are Arabs, Africans, Asians, Japanese, Latin American and Ukrainian.

Besides the term ‘heritage language’, other terms such as ‘ethnic language’, ‘minority language’ or ‘aboriginal language’ have been used. However, in the United Kingdom (UK) and Australia, the term ‘community language’ or ‘where English is an additional language’ were chosen in order to avoid the term ‘heritage’ which sounds traditional and associated with the past (Baker, 2006). The structure and the content of such programs vary, and overlap with the dual-language model of bilingual education. Some of the common features of heritage language programs are that most of the children come from language minority homes, the parents are given a choice to send their children to mainstream schools or to heritage language programs and the language minority student’s home language will be used at least half of the curriculum time.

The third model of the strong form of bilingual education is Dual Language Bilingual Education (or various other terms that refer to the same model; two way schools, two way immersion, two way bilingual educations, developmental bilingual education, dual language education, bilingual immersion, Spanish immersion, double immersion and interlocking education). This type of education is intended to help native or non-native English speaking people to learn another language and culture in an educational setting.

Typically, a dual language classroom consists of one half of the classroom being English speaking students, and the other half of the classroom containing native speakers of a foreign language. Dual language programs also help to “resolve some of the persistent sociocultural concerns that have resulted from segregated transitional bilingual classes” (Collier & Thomas, 2004, p. 3). Students involved in transitional bilingual classes can be assumed by their peers to be ‘problem students’, creating
social distance or discrimination and prejudice expressed toward linguistically and culturally diverse students enrolled in bilingual classes. However, in dual language classes, the possibility exists to create a context where students from each language group can learn to respect their fellow students as valued partners in the learning process with much knowledge to teach each other. Balanced bilingualism and biliteracy are the goals of this program, and students are expected to become bilingual, biliterate and multicultural.

Lastly, under the umbrella of strong forms of bilingual education is Mainstream Bilingual Education or bilingual education in majority languages. According to Genesee (2004, p. 4), “it is a varied and complex model as each community adopts different programmatic models and pedagogical strategies to suit its unique needs, resources, and goals”. Usually, the aims of such programs are bilingualism or multilingualism, biliteracy and cultural pluralism. Most of the countries that have implemented this model are countries with a bilingual or multilingual population, such as Singapore and Luxembourg, or countries like Japan where there are natives or expatriates trying to become bilingual (Baker, 2006). Bilingualism in regional language and an international language is the aim and outcome of formal education. For example, in Asian countries such as Brunei and Taiwan, there is one dominant indigenous language alongside the intention of introducing a second international language into the school.

In most cases, the international language will be used as a medium of instruction alongside the native language. In Europe, this type of education is often called Content and Language Integrated Learning (CLIL). CLIL is a dual-focused educational approach in which an additional language is used for the learning and teaching of both content and language. This program involves teaching a curricular subject through the medium of a target language. The subject can be entirely unrelated to language learning, for example, history lessons being taught in English in a school in Spain. CLIL is taking place and has been found to be effective in all sectors of education from primary through to adult and higher education. Its reputation of success has been growing over the past 10 years and continues to do so.

Garcia (2009) considered Malaysia’s policy of teaching mathematics and science in English since the year 2003 as a CLIL-type bilingual education, teaching one or two
subjects in a global language. According to her, two conditions need to be present in the CLIL-type of bilingual education; firstly, only a small amount of time is needed in the curriculum, which usually involved one or two subjects with only one or two periods of instruction; and secondly, every child is included. As in the Malaysian context, English is the medium of instruction for mathematics and science subjects only, and every child at every level in national schools is involved in this policy. Even though mathematics and science were taught more than two periods of instruction weekly at schools in Malaysia, the conditions are appropriate in terms of involving two subjects, and including all children. Given such context, this aspect will be the focus of this research, which particularly will look at the language aspects in the teaching and learning of mathematics and science in Malaysia.

Using a different schema than Baker, Hornberger (1991) has classified three categories of models of bilingual education according to their different linguistic, cultural and social goals. The three models are the Transitional Model, the Maintenance Model and the Enrichment Model, as shown in Table 2.2. In relation to the types of program, she differentiated between contextual characteristics and structural characteristics. Contextual characteristics comprise of students’ and teachers’ characteristics, such as socioeconomic status of the students and their first language background and the degree of bilingualism of the teachers, whilst structural characteristics depend on the location of such programs in school and the allocation of the languages used.
Table 2.2 Bilingual Education Models According to Hornberger (1991)

<table>
<thead>
<tr>
<th></th>
<th>Transitional Model</th>
<th>Maintenance Model</th>
<th>Enrichment Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linguistic Development</td>
<td>Language shift</td>
<td>Language goal</td>
<td>Language maintenance</td>
</tr>
<tr>
<td>Cultural Goal</td>
<td>Cultural assimilation</td>
<td>Strengthened cultural identity</td>
<td>Cultural pluralism</td>
</tr>
<tr>
<td>Social Goal</td>
<td>Social incorporation</td>
<td>Civil rights affirmation</td>
<td>Social autonomy</td>
</tr>
</tbody>
</table>

(Garcia, 2009, p. 113)

Another useful typology is outlined by Garcia (2009) in her latest book *Bilingual Education in the 21st Century*. If Baker’s typology is based on the different forms of programs related to the background of the students involved, Garcia outlines her typology through the lens of sociolinguistic concepts of monoglossic and heteroglossic. A monoglossic type of bilingual education comprises programs such as Transitional, Maintenance, Prestigious and Immersion while other types of programs such as Immersion Revitalization, Developmental, Poly-directional or two-way (dual language), CLIL and CLIL type, and Multiple Multilingual are classified under the heteroglossic type of bilingual education.

In monoglossic bilingual education, the desired outcome was either proficiency in the two languages according to monolingual norms for both languages, or proficiency in the dominant language according to monolingual norms. On the other hand, heteroglossic bilingual education offers wider choices of programs for the contemporary global language situations. This type of program supports the development of bilingualism and accepts the fact that many children come from homes and communities that have some familiarity with bilingualism.

The models discussed in this section have provided a perspective on bilingual education models around the world and their different practices and goals. The following section will discuss the experience of bilingual education, and the focus will be given to the issues of teaching and learning through a second or third language.
2.1.2 The experience of teaching and learning in a second or third language

Teaching and learning in a second or a third language is not an easy task. Teachers and students involved have to struggle in order to cope with the language policy that requires them to teach or learn in an unfamiliar language. There is no doubt that in the learning process, language is the most important tool to transfer knowledge and skills. It is impossible for learning to occur effectively if the language of instruction becomes a barrier to the learners.

Learning through a second or third language is a common practice in a bilingual education program, and this section will discuss in some detail the experience of bilingual education. It has been the experience of many countries with numerous types of programs that bilingual education has been a success. Garcia (2009, p. 11) contends that bilingual education “is good for all, be it the rich and the poor, the powerful and the lowly, indigenous peoples and immigrants, speakers of official and/or national languages, and for those who speak regional languages”.

The success of bilingual education programs has been reported in a number of countries around the world. Evidence from a number of studies and experiments indicate that bilingual schooling can improve basic education in developing countries (Igboanusi, 2008). Several studies have demonstrated clearly that bilingual education confers pedagogical advantages ((Baker, 2006; Benson, 2002; Cummins, 2000; Dutcher, 2001; Lin, 1997; Youssef, 2002). Besides, bilingual programs address educational quality issues by promoting successful literacy acquisition (Benson, 2002) and biliteracy (Hornberger, 2002) and affective factors such as improved motivation and self-esteem (Dutcher, 1995).

However, in countries such as Asian and most African countries, it has been reported otherwise (Brock-Utne & Holmarsdottir, 2004; Haron, Gapor, Masran, Ibrahim, & Nor, 2008; Igboanusi, 2008; Probyn, 2006, 2009; Salleh, 2004). The implementation of bilingual education has not worked effectively in these countries due to a number of reasons. Language proficiency is one of the most typical problems that hinder the success of bilingual education programs. Education in English where English is not a dominant language often leads to difficulties and failure amongst learners.
Researchers (Banda, 2000; Brock-Utne & Holmarsdottir, 2004; Haron, et al., 2008; Probyn, 2006) argue that use of a second language or foreign language as a medium of instruction can become a barrier to learning. According to Probyn (2006), post-colonial countries that adopted a colonial language as a medium of instruction faced a similar problem, namely learners’ low proficiency in the language of instruction. Brock-Utne and Holmarsdottir’s (2004) study investigated the language policy and classroom practices in Tanzania and South Africa. They found that a large number of students struggle to learn academic content due to the foreign medium of instruction. Although the language of instruction is in English in secondary school to tertiary level in Tanzania, while in South Africa, English is the language of instruction from Grade Four onwards, classroom practices revealed that code switching and translation were widely used as coping strategies. The actual language used in the classroom is mostly Kiswahili in Tanzania, and isiXhosa (the mother tongue spoken by the majority of the learners in the classrooms observed, as well as the mother tongue of the teachers) in South Africa. This is supported by a report from the Ministry of Education in Tanzania (1998) that “Kiswahili is used in class for teachers to express themselves effectively and for students to understand their teachers. Kiswahili is the de facto medium of instruction in many classrooms” (p.xiii).

As a coping strategy, teachers tend to code switch between the medium of instruction and their mother tongue, or translate everything into the mother tongue to enable student to understand. Gumperz (1982) defines code switching as “the juxtaposition within the same speech exchange of passages of speech belonging to two different grammatical systems or subsystems “(p. 59), while according to Grosjean (1982), “code switching is the alternate use of two or more languages in the same utterance or conversation” (p. 45). Since code switching is regarding as an “illegitimate strategy” in teaching, teachers are always caught in a dilemma. Using two languages in the classroom has not been generally sanctioned, but to fully implement the language of instruction in the classroom can seem to teachers to be like “teaching dead stones and not students” (school CS2 teacher) (Mwinsheikhe, 2002, p. 67).

Probyn’s recent study provides useful insights on the need to change the perceptions of using code switching in the bilingual classroom. Given that generally the teachers and learners share a similar home language, Probyn argued that code switching is a
natural communicative response among them. Unfortunately, code switching has been regarded as “illicit, a sign of linguistic and pedagogic incompetence, rather than a valid communicative strategy” (Probyn, 2009, p. 129). On the other hand, the reasons to code switch appeared remarkably similar as reported in other similar postcolonial contexts in Africa and Asia. Probyn (2009, p. 130) has differentiated two broad categories of code switching in the South African classrooms;

- Code switching from the language of instruction to Xhosa for cognitive reasons in response to learners’ limited English proficiency.
- Code switching from the language of instruction to Xhosa to achieve various affective goals.

Martin (1996) asserts that there is a need to consider code switching in the classroom in the wider context of language policy implementation, rather than to attempt to enumerate the functions of code switching.

Another coping strategy used by teachers is translation, which normally doubles the amount of time needed for learning. Repeating everything in the language of instruction to the home or first language slows down the lesson (Brock-Utne & Holmarsdottir, 2004). Since students are aware that they will be given the translation in their own language, they do not pay much attention to the first language spoken. At the end of the day, the desire to improve language proficiency in the language of instruction will be unsuccessful, while extra time has to be taken to do the translation.

Lack of appropriate training received by both pre-service and in-service teachers to teach in bilingual classroom is one more obstacle in bilingual education. Teachers in Probyn’s (2006) study in South Africa, claimed that no training has been received in terms of teaching through English as the medium of instruction. Their pre-service training has prepared them to teach students with good proficiency in English, while the teachers faced a different scenario in reality. However, this situation is not exclusive to South Africa, since many other developing countries are also facing a similar problem (Eisemon, 1992).

In summary, many countries around the world have had the experience of using other than a first language as a medium of instruction in teaching and learning. Many factors have contributed to the success of such program. The language proficiency of
both learners and teachers in the language of instruction and the support system that has been provided to the teachers were seen as two major challenges that hinder the success of teaching and learning in a second or third language. In the next section, the experience of Malaysia in implementing the policy of teaching and learning mathematics and science in English is presented.

2.1.3 The Experience of Malaysia

Since the implementation of English as a medium of instruction in mathematics and science in 2003, there has been a considerable amount of research reported on issues and challenges in the teaching and learning of mathematics and science in English in Malaysia. Based on the issues and topics being discussed, the research can be classified into different themes including learners’ and teachers’ English language competency, teacher professional development, and the use of purpose designed teaching courseware.

A significant amount of research has been conducted on the language problems faced by primary and secondary students in learning mathematics and science in English. A study by Kiong, Yong and Hoe (2005) indicated that students were not ready to learn in English due to their limited English proficiency. Kiong et al. found that while urban students were doing better than their rural counterparts, a majority of the students were unable to master the basic mathematics skills at a satisfactory level. Research by Yassin, Marsh, Tek and Ying (2009) compared perceptions between two groups of students, namely the Limited English Proficient (LEP) and non-Limited English Proficient (NLEP). The study revealed that NLEP learners have significantly more positive attitudes towards science in English, greater parental support and more experience of using the English language than LEP learners.

A large scale study conducted by Haron, Gapor, Masran, Ibrahim & Nor (2008) involving almost 4000 Year Five students from all over the country discovered that a large number of students have low proficiency in English associated with not performing well in mathematics and science. The majority of the respondents found it hard to comprehend the teaching in English. Other language difficulties faced by students were lack of vocabulary and confusion with certain words (Zubir, 2003) and
difficulty in understanding non-scientific terms in the scientific context (Samsudin & Ismail, 2004).

Concerning teachers’ language proficiency, studies involving various levels of teachers (primary and secondary) with different settings (rural and urban) and different groups (pre-service and in-service) have been undertaken. A study by Hamidah (2005) involving 575 teachers of mathematics and science indicated that most teachers have a sufficient level of confidence in their teaching using English. However, a high percentage admitted their lack of ability to teach those subjects in English. The main problem for teachers is to explain concepts in English, given their lack of understanding of the linguistic features of subject content (Pandian & Ramiah, 2004). Findings from research by How, Yan, Wan and Kaliappan (2005) revealed that some teachers are not fully confident in areas like pronunciation of words and terms in science. In general, they understand the English language, but their oral skills to teach content in English are insufficient. On the other hand, How et al. (2005) found that teacher readiness for the purpose of implementation of the policy is at an intermediate to high level, but some of them admitted their lack of proficiency.

Many types of program have been progressively developed to train pre-service teachers and in-service teachers to teach science in primary school since the policy of teaching mathematics and science in English was first announced. In order to ensure that teachers of mathematics and science have the basic capacity to use English as a medium of instruction, the English Language Teaching Centre, Malaysia (ELTC) proposed an English language enhancement programme known as English for The Teaching of Mathematics and Science (ETeMS) as an urgent interim measure (Teacher Education Division). The goal of ETeMS was “to enhance the English language skills of Mathematics and Science teachers to enable them to teach effectively using English as the medium of instruction” (Yunus, 2006, p. 1). This program offers an in-service course, in which many teachers have been trained.

Another support program conducted for teachers is the Buddy Support System. This program is created in schools, where a group of teachers will facilitate as resource teachers known as “critical friends” to teachers that requires assistance in terms of problems related to English language (Abdullah, Alzaidiyeen, & Seedee, 2010). Those critical friends act as a reference for the mathematics, science and English
teachers in the school, and should be competent, proficient and skilled in English language. Among the advantages of this programs are the possibilities that are created to enhance the English language skills of the mathematics and science teachers, and to assist teachers of mathematics and science teachers that require support from the perspective of language, pedagogical knowledge, psychological and emotional implementation of ETeMS (Abdullah, et al., 2010).

A conversion course is another program conducted by colleges, where non-science teachers are supported to become science teachers through a six weeks or fourteen weeks program. The aim of this program is to increase the number of teachers who can teach science in English in schools (Yunus, 2006).

Research by Idris, Cheong, Nor, Razak and Saad (2007)’ which aimed to survey Malaysian mathematics and science teachers concerning the professional preparation effort, concluded that pre-service and in-service training was adequate for their professional preparation. Nevertheless, the sample reported that there was a need for enhancing their professional readiness to teach both subjects in English. In addition, they declared that the pre-service training was not enough to develop their confidence to speak English and around 85 percent of them believed that there is a need for training in helping students to learn English.

A study by Zubir (2003) indicates that the ETeMS program was considered by teachers to be neither appropriate nor helpful and the materials given were too high in standard for primary school teachers’ level. The respondents in that study required more relevant English proficiency courses to assist them with their lack of ability in the English language. Related to the fact that the ETeMS program was a one-time event rather than an ongoing learning experience, the mathematics and science teachers in the Tan and Ong (2007) study reported that the program was not really effective in terms of increasing their language proficiency.

Apart from the specific courses and programs introduced to enhance teachers’ language proficiency, the Centre for Curriculum Development of the Ministry of Education collaborated with private courseware companies to develop teaching courseware for each level of study, from primary to matriculation level. A number of studies have focused on particular aspects of the courseware and other forms of delivery technologies. Surveys on the overall usefulness of this courseware found that
the majority of teachers agreed that it is effective and assists them in coping with teaching Science through English (Idris, Cheong, Razak, Nor, & Saad, 2006). On the other hand, observations and interviews with teachers in the classroom showed that not many teachers were using the courseware in the classroom (Fook, n.d.). They also claimed that the courseware slowed down their teaching. Since they had much to cover, they would be behind time if they only depended on the courseware. Koh’s (2006) study found minimal interaction between teachers and learners. Some teachers were found to be mainly using the passive ‘click and show approach’ to explain science concepts using voice-over found in the courseware.

This section reported on research in multiple issues related to challenges of the teaching and learning of mathematics and science in English in Malaysia. The next section will provide a review of studies related to the teaching and learning issues in mathematics and science.

2.2 Language and Learning in Mathematics and Science Classrooms

There has been a lot of research on understanding mathematics and science concepts based on constructivist notions. According to Barnes (2008), “learning is never truly passive” (p. 2). From a constructivist perspective, learning only occurs if we make sense of what happens to us in the course of actively constructing a world for ourselves. Learning is also viewed as a social process, with language and dialogue essential to cognitive development. Cognitive understanding can be achieved through dialogue and collaboration with teachers and peers.

There is an increasing interest in research that examines the interactions between teachers and students as the key determinant of learning. Based on the sociocultural view, what makes human unique is the capacity to communicate with each other, within communities that shared ways of talking, thinking, and social practices. Related to this view, education is seen as a dialogic process. At school, students and teachers collaborate in a surrounding that reflects the values and social practices of schools as cultural institutions (Mercer & Littleton, 2007). As such, the quality of educational dialogue is central to educational success. In this context, language plays an important role. Almost all teaching and learning take place using the medium of
language, verbal and non-verbal, which always includes quite complex processes and interactions (Wellington & Osborne, 2001).

Whether in science or mathematics classrooms, language is one of the substantial elements. Wellington and Osborne (2001) contend that the science lesson is a language lesson, and learning science is similar to learning a new language (p. 2). Gee (2005) established that “no domain represents academic sorts of language better than science” (p. 19). He added that in science, students are required “to use language, orally and in print, as well as other sorts of symbol systems and practices that are at the heart of higher levels of school success” (p. 19). As Sutton (1992) argued, to learn science is to make a link between “a new way of seeing it” and “a new way of talking about it”.

In the teaching and learning of mathematics, language plays a key role as well. Mathematics itself is a type of formal language. This discipline is made meaningful through the use of language, and students need to be allowed to communicate adequately in the language of mathematics (Capps & Pickreign, 1993). More importantly, the specificity of mathematics language makes it different from everyday language, which students need to be aware of.

Language has a range of functions or modes and this thesis is concerned with language in a variety of modes – its patterns of use and also the creation of meaning in a complex classroom situation. There is a complex interrelation between terms in the literature around language, discourse, talk, and semiotic systems. ‘Language’ or ‘languages’ are often referred to the broader sense of language as encompassing not only talk and written text but also the broader semiotic system which includes visual, mathematical and embodied (often gestural) modes. Elsewhere the word ‘language’ is used in the more specific sense of talk, or written text, when referring to the particular ‘language’ the teacher and students are using.

There is some ambiguity about the distinction in that a physical apparatus or model such as the shapes used in geometric modelling has a distinct representational function and purpose. Particularly artefacts specially designed and used for demonstration or illustrative purposes are an important part of the semiotic system through which meaning is jointly developed in a classroom. However in this thesis the term 'artefact' is taken to mean a piece of physical equipment even though it also has
this representational function. Similarly, the material resources teachers draw on and which are often supplied in these classrooms have a semiotic, representational function but they can be divided into physical artefacts, and representational inscriptions on paper or the board, for clarity of description.

2.2.1 Classroom Talk/Discourse

The status of classroom talk has strikingly changed at least over the last thirty years as it has become recognised as a central aspect in the process of learning (Edwards & Mercer, 1987). Educators see “talk” from a different perspective than it has been seen before, and this different view has also received support from other disciplines such as psychology, child development and sociolinguistics. Traditionally, information was mainly transmitted through the teacher’s “talk and chalk”, and the students’ note-taking and written exercises. Most of the students’ talk occurs during their “chorus chant” or reciting what had been learned by rote, and memory tested question and answer (Edwards & Westgate, 1994). In recent years, a lot of research has concentrated on the issue of “language in education”, and specifically focused on how language is organized and used in classrooms.

Several researchers (Barnes, 1976; 2008; Cazden, 2001; Edwards & Mercer, 1987; Alexander, 2000) have provided descriptions and categorizations of classroom talk/discourse. Douglas Barnes was amongst the pioneers to conduct research in classroom discourse. In his study, Barnes (1976) observed and interpreted students’ classroom talk in detail to explore the process of knowledge sharing and constructing. Classroom observation, tape recording, and researcher’s commentary were used to describe the importance of interactions between teacher and students. He suggested that speech and writing are important elements children use to access knowledge and relate it to their own way of viewing the world (p.19).

While acknowledging students’ talk in the classroom context to enhance learning, Barnes (1976) also highlighted the role of the teacher, since to him, it is only through teacher-students interactions that shared meaning can be achieved and understood by students in their own unique way. Another important contribution of Barnes’s research is to see the classroom dialogue as the teacher’s way of maintaining control
of the classroom. Much of the content and intention of the classroom discussion are controlled by the teacher. In such a context, a teacher begins with a kind of acceptable answer to his or her questions to the students, which in most cases disregards the possibility of students engaging in more open interactions.

In his more recent work, Barnes (2008) makes a distinction between two types of talk; exploratory and presentational talk. The former is often used while students are sorting out their own thoughts, which helps them to work on their understanding. The talk is “hesitant and incomplete” (p. 4), because this is the phase where students are usually brainstorming their ideas. On the other hand, the latter is a type of talk that requires students to use an appropriate language, content and manner in order to accommodate the needs of the audience. Presentational talk is frequently more polished and complete than exploratory talk.

In an effort to understand the ways in which knowledge is negotiated in a classroom context, Edwards and Mercer (1987) have provided more insights about classroom talk. In their book, they describe how “common knowledge” or shared understanding is constructed through joint activity and classroom talk. Through observations of lessons in primary schools of 8 to 10 year old children, they show that negotiating knowledge in the classroom is a social communicative process.

Cazden characterized two types of classroom discourse; traditional and non-traditional lessons. Traditional lessons refer to the three-part sequence of teacher-student talk – that being Initiation, student Response, and teacher Evaluation (IRE) or teacher Feedback (IRF) which she identifies as the most common classroom discourse pattern at all grade levels. This is supported by Wells (1999), who claims that the IRE structure takes up almost 70 percent of the discourse in many secondary and primary classrooms. The IRE pattern has been discussed extensively for many years in many research studies, as a pattern that restricts the opportunity for students to talk (Christie, 2002).

In contrast, non-traditional lessons can incorporate sequences of talk that offer students greater opportunity to talk, as a result of different educational goals. In this type of discourse, teachers still ask questions, but treat student responses differently from the IRE structure and have more room for discussion. Even though most studies on classroom discourse categorized the IRE/F structure as a constraint to students’
talk, Cazden (2001) concluded that both traditional and non-traditional structures are relevant in classroom discourse depending on the specific learning objectives.

Another valuable insight on classroom discourse is provided by Alexander (2000) through observations in the primary school classrooms of five countries: England, France, India, Russia, and the USA. In his study, Alexander established that throughout the world, teachers employ different versions of the communicative process, which is mostly shaped by the cultural contexts of the school. In most classrooms, talk is dominated by teachers, but it varies between countries and between classrooms. One useful concept he introduced in the study is dialogic teaching. It is an approach based on how teachers and students effectively use talk for carrying out teaching and learning. Through this approach, both teacher and students make contributions and the ongoing dialogue helps students to participate actively and enable them to modify their own understanding. Additionally, it opens up opportunities for students to practice new ways of using language as a tool for constructing knowledge.

In another study, Alexander (2006) maintains that classroom talk is the basic requirement for learning, and the quality of learning depends largely on the quality of classroom talk. He discusses the more productive and less productive aspects of classroom talk in three different countries, namely Britain, America and Europe. The research in British classrooms showed less productive classroom talk, whilst more productive aspects of classroom talk existed in European classrooms. Less productive aspects included less interaction that promotes thinking among students, with many closed questions that indicate a low level of cognitive challenge. In America, most interaction is based on the IRE pattern and teacher centred methods are still dominating the classroom talk. Conversely, European classrooms employed more productive student-teacher interaction. In such interaction, the teacher concentrates on helping students to think and reason appropriately.

2.2.2 Discourse in Science Classrooms

From a sociocultural perspective, science education is considered as a process of enculturating students into the particular ways of knowing and representing the world
and making claims associated with scientific perspectives. The role of language is essential in this process. At the same time, researchers (Gee, 2005; Lemke, 1998b; Norris & Phillips, 2003; Unsworth, 2001) maintain that the student is required to attain the particular languages, vocabulary and representational practices of the discipline in learning science. In order to engage in scientific discourses, students need to master the language of science to become scientifically literate. In this case, forms of discourse to support learning activity especially scientific inquiry are fundamental in a science classroom.

Mortimer and Scott (2003) argue that teacher and student talk is important in the science classroom as a way to enable teachers to introduce the scientific view to the classroom and to support students in making sense of that view, as well as to enable the students to engage consciously in the dialogic process of meaning making. Learning science involves being introduced to the language of the scientific community, which is used to talk and think about the natural world in a special way. This language however, is different from an everyday social language, a language that is used in day-to-day communication.

Everyday social language is used to talk and think about the world around us, and shapes our view of our surroundings. Additionally, everyday social language involves informal or spontaneous concepts that are referred as ‘alternative conceptions’ or even ‘misconceptions’ in science education. Another important aspect that needs to be differentiated is the social language of science and the social language of school science (Mortimer & Scott, 2003, p. 14). The distinction between the two types of language is that the social language of school science concentrates on ideas and ways of thinking within the framework of the curriculum.

In relation to the above ideas in the formal setting of the school, students are required to articulate scientific ideas through the school science language. Students need to have the ability to move between everyday language and school science language, since there are many contexts in which those two languages overlap. Misconceptions might be avoided if students have a mature understanding of the similarities and differences between everyday and school language. Given such, an effective student-teacher interaction in the science classroom might be a way of achieving more
meaningful learning, and more importantly, as a way of supporting the development of the students’ school science language.

In developing a framework of student-teacher interactions in science classrooms, Mortimer and Scott (2003) identified four fundamental classes of a communicative approach. These approaches are defined by characterizing the talk between teacher and students along each of two dimensions: dialogic - authoritative and interactive - non-interactive (p. 33). When more than one point of view is being heard in a classroom discourse, it is referred as dialogic, while authoritative refers to an approach when only one voice is recognised. In the first approach, any exploration of different ideas is encouraged. In the dialogic – authoritative combination dimension, a teacher works with students to develop ideas and understanding in the classroom.

The other dimension is from interactive – non-interactive, where interactive is a type of discourse that involves the students’ and the teacher’s participation; while non-interactive is a type of discourse which allows only the teacher to speak. During an interactive episode, the teacher and students interact through questions and answers. However, in a non-interactive episode, a “lecturing” style is used by the teacher. This communicative approach is suggested to be chosen and used by teachers depending on their stage in a series of lessons. No approach is superior or better than another, as it is rather the quality and appropriateness of employing it in the classroom discourse.

Recently, many studies in science education have focused on the importance of representational aspect in learning this subject (Ainsworth, 199; Kress, 2003; Lemke, 2004). These studies contend that in learning science, students must understand and integrate different representational modalities or forms. Particularly, students need to know and understand that there are different representations of science concepts and processes, and they must have the ability to translate the representations into one another. At the same time, students must also be able to coordinate the representations to represent scientific knowledge and explanation building (Hubber, Tytler, & Haslam, 2010). Lemke’s ideas on social semiotics are discussed in section 2.2.5.1.

In relation to the representational aspect, there is a mixture of languages in science discourse, which entails multimodal forms of representations, in which linguistic, numerical, and graphic and tabular modes are linked to represent scientific
explanations. (Prain, Tytler, & Peterson, 2009, p. 788). According to Prain et al. (2009), “multimodal representations refers to the integration of different modes to represent scientific processes, findings, and explanations”, while “multiple representations refers to the capacity of science discourse to represent the same concepts or process in different modes” (p. 788). Analyses of science classroom discourse then should also include how students and the teacher negotiate the multimodal representation aspects in their particular teaching and learning context. Thus, there is more complexity in language negotiation in bilingual classrooms than between first, and second or third languages.

2.2.3 Discourse in Mathematics Classrooms

According to Setati and Adler (2000), mathematics has a specific register and specific discourses. Conceptual and abstracted forms in mathematics require learners to learn mathematics in a way similar to learning a new language. This involves acquiring communicative competence in mathematical language, as a means to express the meaning of certain concepts in mathematics.

Besides that, mathematical language also consists of both formal and informal components. Formal language is the standard use of mathematics terminology, while informal language refers to everyday language that students use to talk about mathematics (Setati & Adler, 2000). Even though formal language is normally exposed to students in formal settings such as schools, both formal and informal language are used in most mathematics classrooms in both spoken and written forms.

In relation to formal and informal language in mathematics, Nesher (in Sfard et al., 1998) made a distinction between talking mathematically and talking about mathematics in a discussion about the importance of learning mathematics through conversation. According to her, two types of languages are used in mathematics classrooms, which are the natural language that is used in everyday situations, and the formal language of mathematics. Nesher further argued that even though both types of languages are employed in mathematics classrooms, and both languages are crucial in learning mathematics, students will be evaluated based on their ability to talk mathematically, and not by talking about mathematics in natural language. She also
emphasized that many mathematical and scientific terms have different meaning in natural language, such as *function*, *root*, *integral* and *height*. To have the ability to differentiate between both languages is critical for students as a way of increasing their mathematical understanding.

Meanwhile, Cobb (in Sfard, et al., 1998) argues that there are distinctive discourses in mathematics classrooms, which he differentiates as calculational discourses and conceptual discourses. Calculational discourse refers to discussions in which the primary topic of conversation involves any types of calculational process. This particular discourse does not refer to conversations that focus on the procedural manipulation of conventional symbols. On the other hand, conceptual discourse refers to discussions in which the reason for calculating in particular ways can also become a topic of conversation. Particularly, in conceptual discourse, students’ calculational processes as well as the task interpretations that underlie the ways of calculating are included (p. 46).

### 2.2.4 The Importance of Multimodality in Mathematics and Science

Try to imagine a mathematics or science lesson where a teacher uses only a spoken and written form of natural language from the beginning to the end. Simultaneously, the students could only hear and read, or speak, and could only gather new knowledge from the speech and writing presented in natural language. If this kind of a lesson were to practically happen in a mathematics or science class, it seems difficult to imagine the lesson could achieve the learning objectives successfully. The reasons for this are related to the importance of a multiple modes of representation to ensure a meaningful teaching and learning process in mathematics and science lesson. Different modes of representations such as 3D artefacts, gesture, and video, play a different but yet important role in a mathematics or science lesson. Without such representations, those lessons would become incomplete, and prevent the teachers achieving their learning goals.

There has been an increasing body of research about the role of representation in teaching and learning. In social semiotics, research has established the central role of multiple and multi modal representational practices in teachers’ classroom activity.
Recently a strong focus has been on representation as an essential element in learning in mathematics and science classrooms. Kress et al. (2001) maintain that “learning can no longer be treated as a process which depends on language centrally, or even dominantly” given the multiple modes of representation that are active in the classroom are also given equally serious attention. The role of representation is strongly emphasized in teaching and learning science, as many studies have shown (Ainsworth, 1999; Jewitt et al., 2001; Lemke, 2004; Hubber et al., 2010; Tytler et al., 2013).

Ainsworth (1999) for example, examines how multiple representations can be used to support cognitive processes in learning and problem solving. By presenting a functional taxonomy of multiple representations, this study recommended the variety of roles multiple representations can play to support learning. It suggested three important functions of multiple representations in learning situations, which complement information or support cognitive processes, constrain possible (mis) interpretations in the use of another, and construct a deeper understanding of a situation (pg 134). As for students, they need to know and understand the different representations, and they must have the ability to transfer between these representations which include 2D diagrams, mathematical representations, artefacts, written text and talk. Jewitt et al. (2001) suggest that multimodality is central to learning and it involves the transformation of information across different communicative systems such as from speech to image. Interplay between visual, actional and linguistic communication becomes substantial particularly in science education where action and image play important roles in the classroom, as well as in the curriculum. By describing a classroom sequence in force that focuses on representations and their negotiation, Hubber et al. (2010) establish that representations are critically important in learning science. Both the teacher and students must be aware of, and be prepared to translate and negotiate the multiple modes of representations that are accessible to them in their teaching and learning journey.

In mathematics as well, meaning is constructed through a range of meaning-making resources and in more than one modality (O’Halloran, 2005; Schleppegrell, 2007; Solomon, 2009; Moschkovich, 2010; Gutiérrez et al.; 2010). Multiple modes are also
used to construct meaning in mathematical discourse. For instance, O’Halloran (2005) has made an analysis of mathematical texts and shows how three semiotics systems which are mathematical symbolism, visual display, and natural language together construct mathematical meaning in ways that natural language alone does not. In reviewing research that highlighted the linguistics challenges of mathematics learning, Schleppegrell (2007) emphasizes that mathematics depends on multiple semiotic systems to construct knowledge. Oral language, written language, symbols and visual representations such as graphs and diagrams are essential parts of mathematics discourse. All elements work together to construct meaning as the teacher and students interact in discussing a problem. At the same time, the technical register of mathematics plays an important role in teaching and learning mathematics, which then becomes a challenge for a teacher and students to translate among all other elements.

**Vygotsky’s Ideas of Mediation**

Vygotsky (1986) regarded tools as mediators by which language plays a crucially important role in learning. Students are dependent on representations as mediating tool to enable them to make meaning of mathematics and science in school. According to Vygotsky, words could be seen as tools in social practices. The idea of mediation, foremost by language but also through other mediating artefacts like images, diagrams, formulas and graphs has influenced educational research ever since Vygotsky’s days, leading to approaches like situated learning, mediated action and pragmatism. One of the pragmatists influenced by Vygotsky was Pierce, who formulated a triadic view on *signs, meaning* and *referents* where signs are representations. Meaning is the sense that learners make of the representations, and the representations refer to something in the world. Several researchers have represented the triadic relation, and Figure 2.1 is the way that Waldrip and Prain (2013) choose to do it. We can see from this perspective how not only words, but also visual and symbolic tools such as diagrams, formulae, gestures, as well as artefacts demonstrated by the teacher, all contribute to meaning making through their mediating roles.
2.2.5 Second Language Learning in Mathematics and Science

Teaching and learning mathematics and science in a language that is not the learner’s main language is complicated. As mentioned before, learning mathematics and science have elements that are similar to learning a language, since both disciplines involve a specific register, set of discourses, as well as conceptual and abstracted forms (Setati & Adler, 2000). Teachers involved are always reported as having a dual task, in which they face the demand of teaching both language and content at the same time. Learners, on the other hand, are required to deal with learning the new language of mathematics and science, and also the language of instruction. Additionally, in learning mathematics and science, learners are required to acquire the formal language of each subject, which is different from everyday language.

Adler (cited in Setati & Adler, 2000) claims that the challenge of learning in this particular situation becomes a three dimensional dynamic. Simultaneously, it includes access to the language of learning, mathematical or scientific discourses, and classroom discourses. The diagram below shows the complexity of the situation for learners and teachers in their teaching and learning journey.

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**Figure 2.1** Pierce’s triadic model of meaning-making (Waldrip & Prain, 2013, p. 17)

- **Representation or sign:** verbal, visual, mathematical, embodied, multi-modal
- **Referent in world (‘object’):** physical object, experience, artefact
- **Meaning:** Sense made of sign, concept, idea, explanation

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In science and mathematics classrooms that use a second or third language as the medium of instruction, teachers are faced with challenges to encourage students to move from their informal spoken language to formal written mathematics or science language. Both informal and formal languages are used in most mathematics and science classrooms, which include spoken and written forms. Based on the diagram in Figure 2.1, there are several possible routes that can be followed in order to achieve both the formal spoken and written form of mathematics and science.

The movement from informal spoken to formal written in mathematics and science is at three level, from spoken to formal written language, from main language to the language of instruction, and from informal to formal mathematical or scientific language. For example, one possible route could be to encourage students to write down their informal utterances in the main language, then write them in the informal language of instruction, and finally formalise the written form in the language of instruction. Another possible route is to translate the informal spoken mathematics or
science language into spoken form in the language of instruction, and then work on the formal mathematics or science language (Setati & Adler, 2000, p. 249).

However, learning mathematics and science does not only involve movement from spoken to written language. As mentioned before, students are also required to negotiate meaning through different kinds of multimodal representation. They need to understand and at the same time to integrate, coordinate and translate information from one modality to another. In this case, in a second or third language mathematics and science classroom, this aspect could be more complicated. Teachers then have another task, which is to facilitate students’ understanding of the multimodal representations together with other tasks that they have already faced in teaching in second language mathematics and science classroom. Students on the other hand, are required to deal with the multimodal aspects of representations in their second or third language, besides other needs such as learning the new language of mathematics and science, and the new language of instruction. Arguably, this aspect is crucial in learning mathematics or science in a second or third language, but as yet too little attention has been given to it in the research literature.

2.2.6 A Broader Perspective on Discourse

In the previous section, the focus has been on a number of specific discourses that are used in science and mathematics classroom contexts. This section intends to define discourse in a more complex and broad way, especially in describing how discourse and semiotic perspective can provide a lens to investigate how languages are used and negotiated in mathematics and science classrooms.

‘Discourse’ and ‘discourse’

The term “discourse” has taken various and sometimes very broad meanings. In this study, discourse is defined according to Gee’s (1990) work. He explored the concept of discourse, and distinguishes between discourse (small ‘d’) and Discourse (big ‘D’). The former is referred as the language-in-use. It is limited within linguistic approaches in relation to text, communication and language, and is part of Discourse.
The latter concept looks at discourse in a broader perspective by taking into consideration the social, cultural, political and contextual aspects. Gee defines Discourse (big ‘D’) as a socially accepted association among ways of using language, of thinking, feeling, believing, valuing and of acting that can be used to identify oneself as a member of a socially meaningful group or ‘social network’, or to signal (that one is playing) a socially meaningful ‘role’ (p143).

He explains that a Discourse is like an “identity kit”. The “identity kit” provides “appropriate costume and instructions on how to act, talk, and often write, so as to take on a particular role that others will recognize” (1989). Furthermore, Gee claims that Discourse needs to be acquired in order to be accepted as a member of a community. He proposes enculturation (apprenticeship) into social practices through scaffolded and supported interaction with people who have already mastered the Discourse. Since Discourses are not bodies of knowledge, they cannot be taught and can only be achieved by practice. Another important aspect of Gee’s view on language is the concept of language usage. He argues that language is always used from a perspective, and always occurs within a context. Therefore, meaning is socially constructed within Discourse communities.

**A Social Semiotic Perspective**

Halliday and Hassan (1985) define semiotics as “the study of sign systems”, “in other words, as the study of meaning in its most general sense” (p. 4). According to Lemke (1998b), “semiotics is the study of how we make meaning using the cultural resources of systems of words, images, symbols, and actions” (p. 3). Every object and action is regarded as a sign, and as having a meaning that goes beyond its properties.

Social semiotics on the other hand, is a theory of how people make meaning of and to one another, and make sense of the world (Lemke, 1990). In other words, this theory concerns everything that people do that is socially meaningful in the community, for example, talking, writing, and drawing pictures and diagrams. The most important idea is that social semiotics looks at those meaning making practices and activities as social processes, where people learn to do something as members of communities, in
which they tend to indicate their community much more than their individuality (Lemke, 1998b, p. 3).

Viewed from this perspective, it becomes clear that each society has its own ways of making meaning which depend on the conventions of how to make meaning in a particular context. This means not only that different people can make different meaning for the same thing, but that the same person can also make different meanings for the same thing at different times. More importantly, people can only make sense of something and to one another if they share the same ways of making meaning.

Lemke (1998b) argued that besides the scientific register of science, there is a broader sense of “the language of science” which is essential in the teaching and learning of science. From the sense of cultural systems of semiotic resources in science, there are the languages of “visual representation, the languages of mathematical symbolism, and the languages of experimental operations”, and the goal of science education should be “to empower students to use all of these languages in meaningful and appropriate ways, and above all, to be able to functionally integrate them in the conduct of scientific activity” (Lemke, 1998b, p. 4).

In both mathematics and science, we rely on a combination and interaction of multimodal representations such as words, diagrams, animations, graphs, equations, tables, charts and models. All of these have their own importance and limitations, and convey meaning in different ways. There are certain meanings we wish to convey that cannot possibly be put across in words alone. Messages and meanings in charts and graphs, for example, can never be replaced by the written word (Wellington & Osborne, 2001).

In his observations in science classrooms Lemke (1998b) has analysed how multiple semiotic resources are integrated in a classroom context, from a student’s perspective. From that analysis, it is clearly evident that the student needs to negotiate many different semiotic systems in his science lesson. It includes listening to the teacher’s spoken words, looking at diagrams, lists, tables, calculations and equations that are written both on the chalkboard and displayed on an overhead projector screen. At the same time, the student is also engaged with other activities such as copying from the board and listening to his classmates’ answers to the teacher’s questions. His
notebook also contains multiple semiotic resources which include words, tables, diagrams, equations and calculations (Lemke, 2003).

Thus, it is strongly suggested that effective learning of mathematics and science can only be achieved by cross-referring and integrating the multiple semiotic resources thematically. It is not possible to get a complete and correct meaning in mathematics or science classrooms if the teachers and the students depended on only one aspect of the semiotic resources. In the process of achieving meaningful learning, students must not only make sense of the multiple semiotic resources, but they must understand the special ways in which the teacher combines and integrates them with each other (Lemke, 1998b, p. 8).

### 2.2.7 The Perspective of My Research

The preceding literature review identified various elements that will underpin the perspective of this research. These elements include classroom talk/discourse in general, specific classroom discourse in mathematics and science classrooms, second language learning in mathematics and science, discourse, and social semiotics. These elements can be consolidated in the following way.

Learners in mathematics and science classrooms need to understand the different task of co-ordinating multimodal representations. This is recognised as a classroom issue and has implications for the classroom context worldwide. Given such a context, it is the intention of this research to uncover how these tasks are accomplished in mathematics and science classrooms taught through a language that is different from the students’ and teachers’ first language. This research is interested in identifying the strategies that are used by both the teacher and students in dealing with multimodal representations in second language learning in mathematics and science classrooms.

Of particular interest to this research is the notion of understanding the multimodal representational aspect. This aspect could be a new potential way of understanding the difficulties of and potential strategies for learning mathematics and science in a second or third language. Lemke (1998b) claims that most students are unfamiliar with the ways in which multimodal representations must be combined to make
complete meanings. If this seems to be one of the major difficulties faced by students in learning mathematics and science, the question is how students who learn these subjects through a medium of instruction other than their first language deal with this difficulty. It might be more difficult for them, since they already have to face the challenges of learning the new languages of mathematics and science, as well as the language of instruction. Therefore, this research intends to look at this issue from the perspective of second or third language learning. On the other hand, the task of coordinating multiple representations may open up possibilities of strategies to support these learners.

One main research question with four subsidiary questions will direct the research. The subsidiary questions are interrelated and signalled the exploration of various elements of the role of language in mathematics and science classrooms that are taught in a second or third language. The main research question and the subsidiary questions are explained below. “Language” in each case is taken to include non-verbal modes of representation, and every day and formal scientific language.

The main research question is:

RQ: How is language, which includes multiple modes of representations used in mathematics and science classes taught in a second or third language?

The main question serves as a focus of the study, which in general concerns how the language is used in the classrooms, from various perspectives that includes the participants, time, events and languages.

The subsidiary questions are:

SQ1: What patterns of language use occurs in mathematics and science classes taught in a second or third language?

SQ2: What is the relationship between the different pattern of language use and types of interactions in mathematics and science classes taught in a second or third language?

SQ3: What are the situational influences on teachers’ and students’ choice of languages in mathematics and science classes taught in a second or third language?
SQ4: How do different representations and artefacts support teaching and learning mathematics and science classes taught in a second or third language?
CHAPTER 3
Methodology

The purpose of this study is to investigate the role of language in mathematics and science classroom taught in a second or third language. This chapter details the research methodology and principles underpinning the study.

3.1 A Qualitative Study

Qualitative research, as defined by Punch (2009), is “an umbrella term that encompasses enormous variety”, which involves multiple methodologies and research practices (p. 115). Merriam (1998) considers qualitative research as an umbrella concept that relates to the orientation of understanding and explaining the meaning of social phenomena. It is based on the perception that reality is constructed by individuals interacting with their social worlds. According to Denzin and Lincoln (1998):

Qualitative research is multimethod in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them. Qualitative research involves the studied use and collection of a variety of empirical materials-case study, personal experience, introspective, life story, interview, observational, historical, interactional, and visual texts-that describe routine and problematic moments and meanings in individuals’ lives (p. 3).

Qualitative researchers are concerned to understand “how people make sense of their world and the experiences they have in the world” (Merriam, 1998, p. 6). The assumption is that meaning is embedded in people’s experiences and that this meaning is mediated through the researcher’s own perception. Naturalistic is the major characteristic of qualitative research, whereby its study focuses on people, things and events in their natural settings. The main concern of a qualitative research is to understand the phenomena of interest from the lens of the participants, which is
the *emic* or insider’s view, rather than from the outsider’s view, or the *etic* (Merriam, 1998, p. 6).

This study is conducted in a natural setting without any manipulation and controlled variables. This provided a platform to investigate the role of language in mathematics and science classrooms that may be discovered using an interpretivist lens. To gain deep understanding, emphasis is given to acquiring rich information that can only be achieved based on a purposively selected sample rather than randomised sample. Qualitative data collected from video recording, observations, and interviews provide better understandings on the meaning constructed by participants. This research aims to construct a perspective through which meaning can be achieved, with the goal of gaining insights rather than results.

As a qualitative researcher, the researcher herself is considered as the primary instrument for data collection and analysis (Merriam, 1998). This means that the research is mediated through the researcher, rather than through inanimate tools such as questionnaires or computer generated analytical systems. A human researcher has the ability to be responsive to the context, adapt techniques to the circumstances, consider the total context, process data immediately, clarify and summarize as the study evolves, and can explore anomalous responses (Merriam, 1998, p. 7).

In relation to the above context, Denzin and Lincoln (1998) indicate that qualitative researcher’s observations could be blended with the participants’ observations through interviews, case study or other documents. In this respect, the researcher is believed to report his or her own observation and experiences with objectivity, clarity and precision. However, it has to be acknowledged that being immersed in the participants’ contexts, the role of the researcher is not detached. Inevitably influences such as the researcher’s background or the interview questions that are prepared by the researcher may shape the process of interpreting the participants’ behaviour, as well as the way in which the participants’ responded to the questions.

### 3.2 Multiple Case Study

This research will employ a multiple case studies approach, as it will involve two secondary schools in Malaysia. Punch (2009) categorises this approach as collective
case study, where the study aims to give insight into an issue, or to refine a theory, in which involves multiple cases. In describing the term “case”, Yin (2009) suggests that it is referred to an event, an entity, an individual or even a unit of analysis. It is an empirical inquiry that investigates a contemporary phenomenon within its real life context using multiple sources of evidence. In the case of multiple case studies, both Yin (2009) and Stake (2005) agree that the main reason for conducting a case study is for replication rather than representativeness. Additional cases are chosen because such cases are expected to yield similar information or contrary but predictable findings (Schwandt, 2001). They do not aim at providing generalisation.

In relation to this research, multiple case studies will be conducted in which two secondary schools will be involved. Four teachers and four Year 2 classes from each school will be invited in order to get some variations of different mathematics and science classes in different schools. Different classes, teachers and schools selected in this research are for the purpose of variety rather than representativeness.

In this research, the case study approach allows the detailed descriptions of people, contexts and events in order for the researcher to get a deeper understanding of their real life situations. As Patton (1987) suggests, case study can be used to probe an area of interest in depth. This study aims to gain a deeper understanding of patterns of interactions in mathematics and science classrooms. Its purpose is to get rich descriptions of language interactions, not primarily aiming to describe the quantity of interactions that occur in the classrooms. For that reason, case study becomes the choice, which allows the researcher to gain a full understanding of the language aspect by focusing on the selected cases.

One of the common issues in conducting a case study is the generalisability of the results of the study. Merriam (1998) asserts that the question of generalisability has plagued qualitative researchers for some time. Generalisability refers to the degree to which the findings can be generalised from the study sample to the entire population (Polit & Hungler, 1991 cited in Myers, March 2000). As mentioned earlier, the goal of this study is to understand language interactions in mathematics and science classrooms. In this context, small sample size is more useful to examine the situation in depth from various perspectives, whereas a large sample would be inconsequential (Myers, March 2000). Small samples may allow more personal understanding of the
phenomenon and the results of this study can potentially contribute valuable knowledge to the community.

In any research, validity, reliability, and ethics are major concerns. The question of validity in this research is addressed by using triangulation, presenting a multiperspectival interpretation through interviews, classrooms observations, and clarifying researcher biases and assumptions. Data triangulation, describing in detail how the study is conducted, and how the findings are derived from the data, will enhance the reliability of this research. Ethical issues of this research will be discussed in the next chapter.

Reliability and validity of qualitative research is also conferred through the rigour of the process of selecting and analysing data and making clear the basis on which these decisions are made, so that the reviewer of the research has a clear sense of the trail of evidence, and how it supports the conclusions.

In the research, I have kept a clear audit trail of all the processes of selection of participants, generation of data through interview or observation; analysis processes; selection of particular teachers, and excerpts of classroom transcripts used to support analyses and eventual conclusions. I have been careful to make this chain of decisions clear and transparent in reporting on the research. Thus, reliability and validity of this research is evidenced through the careful documentation and justification of decisions made, leading to the findings and conclusions.

3.3 Interpretive Research Paradigm

The nature of research inquiry can be from two perspectives, normative and interpretive. Interpretive inquiry aims to characterize how people experience the world, the way they interact together, and the settings in which these interactions take place. This paradigm looks at reality as being internally experienced, and in the minds of the people involved in the research. This research will take the interpretive paradigm, whereby, the researcher, the teachers and the students involved in this research will each have their own knowledge base and perceptions of the realities of the language usage in the classroom.
The researcher and the participant are linked such that who they are and how they understand the world is a central part of how they understand themselves, others, and the world. Besides, the interpretivist researcher tends to rely upon the participants’ views of the situation being studied, and recognises the impact on the research of their own background and experiences (Cresswell, 2003). This research is not searching for truth but rather looking for insight.
CHAPTER 4
Research Design

This chapter will detail the procedures to be employed in this research. It is divided into five sections. In the first section, the overview of the research design is presented. The second section discusses the selection of sites and participants, whilst the third section describes the data collection procedure. In section four, the data analysis procedures are presented. Finally, the ethical implications related to this proposed study are discussed.

4.1 Overview of the Research Design

In this research, the researcher intends to investigate how languages that include multiple modes of representation were used in mathematics and science classrooms in Malaysia through a medium of instruction of other than first language. For that reason, two secondary schools in Malaysia were chosen, in which two science and two mathematics classes of Form 2 (equivalent to Year 8) students from each school, were involved. The purpose of choosing Form 2 students is because the Form 2 students are the first cohort that learnt mathematics and science in English since they started their formal education in Standard 1 (equivalent to Year 1) in 2003. Most secondary schools in Malaysia have a range of different classes for every level of study, which are divided based on the students’ academic achievement. Two top mathematics and science classes and two bottom mathematics and science classes from each school were selected in this research, as a way of getting a variety of English competency among students.

Data was gathered mainly from classroom video-recording, and also interview and classroom observation. All science and mathematics teachers for all classes involved, and two to five students from every lesson recorded, were subjected to a video-stimulated recall interview, in order to gain from their perspectives more insights into language interactions, teaching and learning strategies, and purposes. The researcher’s field-notes from classroom observations provided a context for each lesson, as well as
a supplement for the transcripts. All tools used in this research were piloted prior to
the actual study.

4.2 Selection of Sites and Participants

As mentioned earlier, this study involved two secondary schools in Malaysia. Cohen,
Manion and Morrison (2000) assert that the quality of a research study depends
considerably on the strategies of sampling chosen in doing the research. Researchers
must carefully decide on who will be researched, the setting of the research, and the
procedure to be applied. This section will discuss the selection of sites and
participants in the research.

4.2.1 Purposeful Sampling Strategy

Purposeful sampling is based on the assumption that the researcher intends to
“discover, understand, and gain insight and therefore must select a sample from which
the most can be learned” (Merriam, 1998, p. 61). This strategy is aimed at generating
a sample of information-rich cases that can be studied in depth. Different types of
purposeful sampling can be chosen in selecting the sample, such as typical, unique,
maximum variation, convenience and network sampling (Merriam, p. 62).

In this research, a typical sample was selected that reflects the average school in
Malaysia. According to Patton (1990), the typical sampling strategy is used when the
selected site is not in any major way atypical, extreme, deviant, or intensely unusual
(p.173). In other words, any school that fits the profile of average secondary schools
in Malaysia could be included in the study. For this reason, two secondary schools in
Malacca, a small state located in southern region of Malaysia, were selected in this
research.

To purposefully select a particular site, the researcher must determine the selection
criteria which need to reflect the purpose of the study. The main criteria that were
used in school selection in this study are location and ethnic composition. Two
schools from different locations, namely urban and rural, were chosen with the
purpose of getting a variety of students’ English language background. A number of
studies in Malaysia (Noreiny Maarof et al., 2003; Hazita Azman, 2006, cited in Jalaluddin, Awal, & Bakar, 2008) indicate that students’ weaknesses in English can be attributed to geographical location and ethnicity. In terms of the geographical location, urban students are found to be more proficient in English than their counterparts in rural area schools. The rationale of including schools from both locations is to open more opportunities for this research to get a variety of data from students with different backgrounds.

In regard to ethnic composition, schools that represent Malaysia’s ethnic composition were selected as a way of reflecting the actual atmosphere of a typical secondary school’s classroom in Malaysia. Malaysia is a multi-ethnic country with Malays and the Bumiputera making up 65 per cent of the population, 26 per cent Chinese, 8 per cent Indian, and 1 per cent of other unlisted group. This study took into account some inevitable limitations. Admitting that every secondary school has the potential to be selected in this research, it is hardly possible to include all secondary schools in Malaysia to be involved. Hence, schools that are close to Malaysia’s ethnic composition were the criteria of school selection in this research. Given practical constraints in the location of schools, this research was conducted in two secondary schools in Malacca, a small state in the southern region of Malaysia.

4.2.2 Gaining Access and Selecting Participants

Researchers can only gain access to schools in Malaysia if they received permission from the Ministry of Education in Malaysia (MOE). First of all, the researcher needed to get the approval from the MOE and then contact the State Department of Education to gain access to secondary schools that were involved in this research. The next step was to approach the principal of both schools, to briefly explain the research and the procedures of the data collection at that school. The teachers and the classes that participated in this research were then identified.

One to two science teachers, one to two mathematics teachers, and four Form 2 classes from each school were chosen as the participants in this study. All students and teachers were involved in the video-recording session, depending on their consent to involvement in this study. Meanwhile, in the interview session, all teachers were
interviewed individually, while only two to five selected students from each lesson recorded were involved in the video-stimulated recall interview.

4.3 Data Collection

In this research, data was collected through the use of video recording, observations and interview.

4.3.1 Video recording

The primary source of data in this study was generated from classroom video-recording. Video recording was employed in this research because it allows a permanent record of classroom events in detail, and unlike audio-taping, captures both verbal and non-verbal interaction. Video-recording provides a rich data source from which a variety of data can be extracted, including dialogue, behaviour and attitudes. More importantly, video-recording is becoming more accessible and useful to research. In this research, two consecutive lessons of each subject in every class were video-recorded. A camera technician was assigned to handle all cameras, in order to enable the researcher to concentrate on the classroom observation. All types of language transaction that occurred in the classrooms were crucial as a source of data.

To ensure that the recorded data is inclusive, two digital video cameras were used simultaneously to capture two different events in the classroom. The first camera captured the teacher and the whole classroom. In other words, it recorded whatever happens in the setting, whether it appears to be important or not. The second camera on the other hand, was used to capture a selected group of students in the classroom. This selected group of students was chosen based on the teacher’s advice.

As the video-recording equipment can disrupt the naturalness of the setting and create an unpleasant environment to the participants, a brief discussion took place with the students in advance. They were informed of the purpose of the recording, and also to familiarise them with the equipment that was used in their classroom.
4.3.2 Video-stimulated Recall Interview and Interview

Video-stimulated recall is a popular research method in education. According to Nespor (1985), “stimulated recall” is a blanket term, which involves many types of interviewing techniques whereby the questions are based on mechanical records of actual classroom activities (p. 193). During a video-stimulated recall, participants watch a video-recording of a specific event in which they were involved, and then discuss their participation in that event (Theobald, 2008, p. 2). It normally involves a video-recording session, followed by an interview between the researcher and the participant, with the video playback used as a stimulus for the discussion.

On the other hand, the main purpose of an interview is to obtain information that mostly cannot be observed directly, such as feelings, thoughts, and experiences. As stated by Fontana and Frey (1998), “interviewing is one of the most common and most powerful ways we use to try to understand our fellow human beings” (p.47).

This research employed a video-stimulated recall interview as a way of eliciting the teachers’ and students’ explanation of how they see their language usage in the classroom. Semi-structured interviews were used in this study in order to explore the participants’ experience of teaching and learning through their second or third language. All teachers were interviewed face to face, whereas only two to four selected students from each lesson recorded were interviewed in a group. The interview was conducted after the video recording session, depending on the flexibility of time allowed by each school.

During the interview session, the video was replayed in front of the participants, and the researcher chose significant events as a starting point for a discussion. Possible questions to ask were prepared for both teachers and students participants, as a guide for the researcher to conduct the interview. Thus, the researcher maintained a passive but stimulating role, trying to be an active listener while taking down notes. All interviews were audio-recorded, and the recording facilities were prepared beforehand to avoid any technical problems.

The researcher also conducted a pre-lesson interview with the teachers, which was held before the first lesson of each class. This interview was used by the researcher to
gain information regarding the teachers’ teaching background, the context of the classes and the lessons, and the teachers’ plans for the lesson sequence beforehand.

At the beginning of an interview, it is essential for the researcher to set up ‘equality of interaction’, as a way of establishing the researcher and participant as equal communicating partners during the interview. Participants were reminded that there is no right or wrong way of answering the questions. Their response should rely upon their own experience and understanding of teaching and learning in the classroom.

According to Merriam (1998), a semi-structured interview is guided mainly by a list of questions to be explored by the researcher. However, the questions need to be more open-ended and allow flexibility for the participants to give their responses. A list of questions for both teachers and students for the video-stimulated recall interview sessions are attached in Appendix 1.

4.3.3 Classroom Observation

Classroom observation was employed in this research, at the same time as the video-recording sessions. Observation can enable a researcher to get direct experience of the classroom and school setting. While collecting information as an observer, a researcher can choose a range of stances, from being a full participant to being a spectator (Merriam, 1998, p. 100). In this research, the researcher intended to occupy a “close to spectator observer” role. To be specific, during the classroom observation, the researcher chose a non-participant technique; while there was a participant role during the reflective interview session. This links to the point made by McCall and Simmons (1969, cited in Guba & Lincoln, 1981), that interviewing the participants may be considered as part of the observation process.

In employing a non-participant approach, the researcher observed all activities in the classroom without being involved in them. Field notes were taken during the observations. The field notes were used for two purposes; to ensure triangulation of data, and to enable comparison with the transcripts. Besides, field notes can also provide a clear link between the video-recorded data and the progress of the activity reported in the notes. Information such as the topic being taught, duration of the
lesson, time, place and date are valuable for the researcher during the transcription of the recorded data. However, the video data is the primary data used in this research, while field notes from the classroom observations served as supplementary.

### 4.4 Data Analysis Procedures

Due to the considerable volume of information gathered from multiple sources, data in this research was stored and managed systematically in such a way that they were easy to locate and retrieve and protected from damage or loss.

Multiple perspectives and practices can be adapted to analyse qualitative data. In qualitative research, data collection and analysis is a simultaneous activity (Merriam, 1998). Large amount of data are often produced in qualitative research, often in the form of text and numbers that needs to be processed to allow interpretation.

In Miles and Huberman’s (1994) approach, there are three main components of data analysis; data reduction, data display, and drawing and verifying conclusions. The three activities are seen as interacting throughout the analysis process. In the data reduction early stages, data are edited, segmented and summarized. In the middle stages, the data need to be subjected to coding and memoing with associated categorising around themes or patterns. In the later stages, the data are conceptualized and explained, as a way of reducing the data. However, the researcher has to keep in mind that data reduction aims to reduce the data without significant loss of information. In the data display component, the data are organised, compressed and assembled. The final component is to draw and verify conclusions.

The language of data collection for the pre-interview and the video-stimulated recall interview was mainly Malay. In the data reduction stages in this research, data gathered from the video and interview were transcribed and translated. The data were transcribed prior to the translation process. Only data that were used in the excerpts discussed in the later chapters were translated. Language translation in the interviews is at the very least a subjective process.

The data then were coded in the middle stages of data analysis. In this process, the researcher selected rich episodes which involve a variety of language transactions, subjected to a discourse analysis. This analysis is broadly drawn on the categories of
discourses that have been described in the literature review chapters, for instance is broadly drawn on the framework of Mortimer and Scott or Alexander.

Transana was employed during this stage to facilitate not only the coding process, but also for organizing data. Transana is a qualitative computer-based analysis tool that allows a researcher working with large collections of video. Various tools and metaphors for organizing, analysing, and retrieving videos, segments of videos, and transcriptions of videos are supported in this software package (Mavrou, Douglas & Lewis, 2007: 167).

### 4.5 Data and Coding Scheme

The main data used in this research is the video data, gathered from two video cameras that captured two different scenes in every lesson recorded. Altogether, 15 lessons were recorded, which overall involved 30 videos to be created into 30 different files in Transana. In the first stage, every file was named based on the abbreviation of the school, subject, type of class, teacher, and type of video. For example, file **RSGKKTF1** referred to *Rural Science Good Kalsom Karim Teacher Filming 1*, while **USMBHFT2** referred to *Urban Science Medium Beng Hong Filming Teacher 2*.

The next stage was to watch every video in order to select videos with rich episodes involving variety of language transactions. In this stage, field notes taken during classroom observations were used as a guide to zoom in to specific segments in the videos. Only selected videos were then transcribed verbatim.

Fleet and Cambourne (1989) emphasize that coding is the researchers’ effort to organize chaotic human behaviour into small ‘bits’ and store it into ‘pieces’, so reducing its complexity. Coding processes happen in Transana by creating and applying keywords to clips or collections. Thus the coding process in this research began with creating keyword groups, which related to the coding scheme that will be discussed further in Chapter 6. There are four keyword groups created, namely Classroom Organisation, Language Use, Types of Interaction and Types of Talk. It is
important to note here that the coding process involves the researcher’s judgements, and that no decisions were made by Transana.

The keyword groups then were used to create clips that were synchronised with the transcript. These processes were done to the video from start to end which automatically created a Series Keyword Sequence Map for every lesson, as used and discussed in Chapter 6.

Other sets of data were gathered from the interviews conducted with all teachers and a group of students from each lesson. All interviews were transcribed verbatim by the researcher. Since Malay was the language dominantly used in all interviews, quotes from the interview data were translated to English before being used in the discussion.

### 4.6 Ethics Implications

Ethical issues that need to be addressed in this research include obtaining consent from participants, maintaining their privacy and protecting them from harm; maintaining confidentiality, and acknowledging the rights of the participants to be informed about the nature and consequences of the study in which they are involved.

This research involved two different groups of participant, namely teachers and Form 2 students in two secondary schools in Malaysia, in which various tools of methods were employed. Classroom video-recording, classroom observation, and video-stimulated recall interview relate to personal interaction which produces information about human behaviour. Privacy, anonymity, confidentiality, betrayal and deception are ethical considerations that need to be handled cautiously.

Schools and teachers were invited in a way that offset any chance that felt they were coerced. Informed consent in writing was sought from the participants to alleviate as many concerns relating to ethical issues. In the consent form, each participant was given a clear explanation of the research purpose, benefits, and methods. It also included the type of data to be collected, the ownership of the data, as well as the storage and the access of the data. Participants’ anonymity was also assured in this research. If any of them wished to withdraw their participation at any point, they had the right to do so. Since this research involved students, parental consent was also
sought. Above all, participation in this research was completely voluntary, and participants were assured there was no obligation to participate in this project.
CHAPTER 5
Overview of the Data

This chapter presents the data that has been collected at two secondary schools in Malaysia, focussing on a description of the research sites, the teachers and the students, the lessons, and the language used by both teachers and students. Further analyses that discuss the participants’ language are contained in subsequent chapters.

The description of the participants is presented as equal as possible involving every aspect discussed. However, in some aspects, such as the number of excerpts showed in every lesson there are differences. The differences were sometimes related to the amount of talk that occurred in the classes, but sometimes also depended on the topics and activities of the lessons.

5.1 The Research Sites

In this section I introduce Melaka, the state where the schools are located, and the types of secondary schools in Malaysia. This is followed by an introduction to the two schools that participated in this research.

Melaka, the third smallest Malaysian state, is located in the southern region of the Malay Peninsula. There are three districts in Melaka, namely Central Melaka, Alor Gajah and Jasin, with a total population of 788,706 as of 2010. Melaka City, which is situated in Central Melaka and is 148 km south east of Malaysia’s capital city Kuala Lumpur, is the capital city of Melaka. From 7 July 2008, the state that is well known as “a historical city” has been listed as a UNESCO “World Heritage Site”. It is rich in cultural heritage and has several places of historical interest. The two most important sectors in the state economy are tourism and manufacturing, and tourism contributes almost three quarters of Melaka’s gross domestic product.

Secondary schools in Malaysia are sub-divided into several types. Amongst the types are National Secondary Schools, Religious Secondary Schools, National-Type Secondary Schools, Technical Schools, Fully Residential Schools and MARA Junior Science Schools. Apart from the government schools, there are private secondary
schools as well, for instance Chinese Independent High Schools and International Schools. The two schools selected in this research, namely School R (rural) and School U (urban), are national secondary schools situated in Melaka.

**School R (rural)**

School R is a co-educational national secondary school which is located in Alor Gajah, the second largest district in Melaka. Alor Gajah is a district with an area of 699 km², and a population of approximately 140,000. It is located 24 km from Melaka City, the state capital, and consists of 31 sub-districts. School R is situated in one of the sub-districts. Alor Gajah is famous for art craft and food products and has small to medium scale industries. Listed as a rural school by the State Education Department, School R has about 1700 students from Year 7 to 13. Four teachers, Zila2 and Bo (mathematics), and Kalsom and Hasnah (science) volunteered, in discussion with the Principal, to participate in this research.

**School U (urban)**

Located in the district of Central Melaka, School U is also a co-educational national secondary school. It is situated in one of the suburbs of Melaka City, and is listed as an urban school. Central Melaka is the smallest district in Melaka, with the area of 279 km², but it is the most populated district with a population of approximately 470,000 residents. This district is the major destination of tourists in Melaka as most historical spots are situated in the district. The suburb where the school is located is in a large industrial area.

The total number of the students in School U is approximately 2100, from Year 7 to 13. The four teachers who volunteered in discussion with the Principal are Lim and Normah (mathematics), and Ahmad and Beng (science). Unfortunately, Lim and Ahmad withdrew. Lim claimed that she was using Mandarin most of the time to teach, which she thought made her unsuitable to participate, as well as for the researcher, who has no Mandarin background. Hence, she introduced Seow, and Seow agreed to give her consent. Meanwhile, Ahmad gave a reason that he had finished the

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2 Names are pseudonyms
syllabus for Year 8 class. After some discussion with Ahmad, he suggested Anis, another Year 8 science teacher as suitable to participate. Anis gave her consent and replaced Ahmad.

5.2 The Research Participants

This section introduces the teachers, the students, the classes, and the lessons involved in this research. An overview of the selected characteristic of the participants at each school is contained in Tables 5.1 and 5.2.

Table 5.1 and Table 5.2 show the characteristics of the participating teachers, students and lessons at School R and School U. In both schools, students are streamed on their academic achievement. The classes are ranked, based on the students’ overall performance at the end of the previous academic year. Students with the best results are placed in the top class, followed by classes with students whose achievements are lower than the students in the top class. All classes are ranked from top to bottom based on their overall academic achievement. Top and medium classes were selected in this research in an effort to ensure variety in students’ competence in English, Mathematics and Science. Thus “8/10” indicates the eight ranked class out of 10.

In regard to the teachers’ level of English, their English was rated as “good”, “average”, or “weak”, based on their own judgement that they made in the pre-lesson interview. Only one teacher, Seow, claimed that her English was at a good level, while others thought that their English level was average, and Normah believed that her English was “weak to average”. Seow is a very senior teacher with more than 30 years of teaching experience, who went through her education exclusively in English. Except for Beng who has been teaching for 20 years, all other teachers have less than 15 years of teaching experience, which indicates that they received their education largely through the national language, Malay. ³

³ Refer Chapter One for further information on the medium of instruction policy in Malaysia.
Table 5.1 Characteristics of Teachers, Students and Lessons in School R

<table>
<thead>
<tr>
<th>SCHOOL R</th>
<th>Mathematics</th>
<th>Science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Teacher: <strong>Zila Rahim</strong>&lt;br&gt;Teacher’s English competency: Average&lt;br&gt;Class level: 1/10&lt;br&gt;Number of students: 32 (Malay)&lt;br&gt;Topics: Statistics (L1) &amp; Frequency (L2)&lt;br&gt;Language used by teacher: Malay and English&lt;br&gt;Language used by students: Malay and English</td>
<td>Teacher: <strong>Kalsom Karim</strong>&lt;br&gt;Teacher’s English competency: Average&lt;br&gt;Class level: 1/10&lt;br&gt;Number of students: 32 (Malay)&lt;br&gt;Topics: Force (L1) &amp; Measurement of Force (L2)&lt;br&gt;Language used by teacher: Malay and English&lt;br&gt;Language used by students: Malay and English</td>
</tr>
<tr>
<td></td>
<td>Teacher: <strong>Bo Yang</strong>&lt;br&gt;Teacher’s English competency: Average&lt;br&gt;Class level: 6/10&lt;br&gt;Number of students: 32 (Malay, Chinese &amp; Indian)&lt;br&gt;Topics: Reflection (L1) &amp; Surface Area (L2)&lt;br&gt;Language used by teacher: Malay and English&lt;br&gt;Language used by students: Malay and English</td>
<td>Teacher: <strong>Hasnah Ahmad</strong>&lt;br&gt;Teacher’s English competency: Average&lt;br&gt;Class level: 8/10&lt;br&gt;Number of students: 35 (Malay, Chinese &amp; Indian)&lt;br&gt;Topic: Stability&lt;br&gt;Language used by teacher: Malay and English&lt;br&gt;Language used by students: Malay, English, Mandarin &amp; Tamil</td>
</tr>
</tbody>
</table>

Key:  
L1 = Lesson 1  
L2 = Lesson 2
Table 5.2 Characteristics of Teachers, Students and Lessons in School U

<table>
<thead>
<tr>
<th>SCHOOL U</th>
<th>Mathematics</th>
<th>Science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Teacher: <strong>Seow Chin</strong></td>
<td>Teacher: <strong>Anis Mahmud</strong></td>
</tr>
<tr>
<td></td>
<td>Teacher’s English competency: Good</td>
<td>Teacher’s English competency: Average</td>
</tr>
<tr>
<td></td>
<td>Class level: 1/14</td>
<td>Class level: 2/14</td>
</tr>
<tr>
<td></td>
<td>Number of students: 28 (Malay, Chinese &amp; Indian)</td>
<td>Number of students: 27 (Malay)</td>
</tr>
<tr>
<td></td>
<td>Topics: Solids (L1) &amp; Surface Area (L2)</td>
<td>Topics: Nutrition (L1) &amp; Calorific Value (L2)</td>
</tr>
<tr>
<td></td>
<td>Language used by teacher: English</td>
<td>Language used by teacher: English and Malay</td>
</tr>
<tr>
<td></td>
<td>Language used by students: Malay, English and Mandarin</td>
<td>Language used by students: Malay and English</td>
</tr>
</tbody>
</table>

|          | Teacher: **Normah Ali**           | Teacher: **Beng Hong**         |
|          | Teacher’s English competency: Weak to average | Teacher’s English competency: Average |
|          | Class level: 7/14                 | Class level: 7/14              |
|          | Number of students: 29 (Malay, Chinese & Indian) | Number of students: 29 (Malay, Chinese & Indian) |
|          | Topics: Rotation (L1) & Linear Equation (L2) | Topics: Support System (L1) & Stability (L2) |
|          | Language used by teacher: Malay, with English for technical terms | Language used by teacher: English, Malay, and Mandarin |
|          | Language used by students: Malay, English and Mandarin | Language used by students: Malay, English, and Mandarin |

Key:  
L1 = Lesson 1  
L2 = Lesson 2
In terms of the language used by the teachers, Tables 1 and 2 demonstrate that all teachers used a mixture of English and Malay in their mathematics and science class except Seow, who used English exclusively in both of her lessons. Some teachers, for example Kalsom, used English and Malay nearly equally, but some others used more English or more Malay to deliver their lessons. The tables indicate the main language used by the teachers. For instance, if the first language listed at the column “language used by the teacher” was English and Malay, it means that the teacher has used more English in her or his teaching. However, if the language used was “Malay and English”, the teacher has used more Malay than English to deliver his or her lesson.

Students on the other hand, used a mixture of languages in their conversation, be it with their teacher or their peers. Most of the time, they used Malay or English to answer questions or to have conversation with their teacher. However, during group work, they used English, Malay or their first language, such as Mandarin for Chinese students, or Tamil for Indian students, to discuss with their group members. In some situations, Chinese students used Mandarin to interact with their Chinese teacher.

In the following sections, I will describe each of the participants thoroughly, starting with School R and followed by School U.

5.2.1 Kalsom Karim (science teacher)

Kalsom is an ethnic Malay whose first language is Malay. She is considered to be a new teacher with four years of teaching experience, all in secondary schools. She graduated from a local education university in 2005, with teaching specialization of Mathematics and Biology. In 2007, she started teaching at School R and taught Science and Moral Studies to Year 7 for one year. The next year, she was given the responsibility to teach Science to Year 8 and History to Year 9. Her class is a Year 8 science class, which is ranked number one out of ten classes in this school.

Kalsom rated herself as “average” for her proficiency in English. What she meant by “average” was that her receptive skills in English are better than her expressive skills. She has the ability to understand spoken or written English without much difficulty, but when it comes to conversing in English, she finds it challenging. She admitted that
lack of practice is the main reason for her English, especially her spoken English, not being as good as it should be. Yet, she believed that her English has significantly improved since she started to teach science in English, which requires her to do a lot of lesson preparation in English. Although the medium of instruction for science courses at the tertiary level is English, most lectures during her undergraduate years were conducted in a mixture of English and Malay. The reference books and lecture notes were largely in English; however some lecturers did provide them with a Malay version of lecture notes.

_Kalsom’s Lessons_

Two science lessons were recorded from Kalsom’s science class. According to Kalsom, the students’ level of Science is good, in comparison with other Year 8 classes. She considered the students as “good” in science based on their performance in the monthly tests and examination results. On the other hand, she rated their English as average. This particular class is a Religious Stream Class, consisting of 32 Malay students. Religious Stream Classes are different from ordinary classes in terms of the number of subjects that the students need to learn. They are required to learn Arabic Language, as well as other compulsory subjects learnt by other students. Even though there are many Islamic Religious Schools throughout Malaysia, the number of students that want to enrol at that type of school is always greater than the number of places offered. In order to provide more places for students to study in a religious stream, the government has created special classes for Islamic Religious Stream at many ordinary national schools in the country.

Both lessons were about “Force”. In Lesson 1, the students were introduced to the concept of force and its different types, while in Lesson 2 they learnt about the measurement of force.

Summary of Kalsom’s lessons

Lesson 1 – Force

Kalsom introduces Force by asking a number of questions about the meaning of force and the effect of force.
She refers to the notes prepared on the white board and in the text book, and uses a variety of materials such as a wooden block and plasticine in order to explain and discuss the topic with the students.

Kalsom then displays a CD-ROM that is supplied by the government, which discusses force with more examples. The explanation on the CD-ROM includes types of force, describing magnetic force, frictional force and gravitational force.

She assigns students to work in groups to test on the magnetic force, and follows this by demonstrations of magnetic force from her table.

Students continue working in groups to do experiments on electrostatic force.

Kalsom continues the lesson with a few examples of different types of force, including ones from the CD-ROM.

Then she distributes an exercise sheet for each student to do individually, using the textbook as a reference. Students are given 15 minutes to complete the task and she then discusses the answers together with the students.

Lesson 2 – Measurement of Force

Kalsom begins the lesson by revising the previous lesson.

She introduces the topic which is “Measurement of Force” by referring to the notes prepared on the whiteboard. Then she introduces the unit to measure force, Newton, and demonstrates to the students how to use a spring balance to measure force.

The students then are asked to try the spring balance with their group.

Then Kalsom discusses the application of frictional force.

She asks the students to complete an exercise, which is to find the reading
for different kinds of materials by using a spring balance, in order to show how different types of surface affect the magnitude of frictional force. She checks and discusses the work with the students in their groups. Then she discusses the answer for each question with the whole class.

Discussion continues with the application of frictional force.

Kalsom ends the lesson by revising all the important aspects that they have learnt today.

The Teacher’s Language

Kalsom used both English and Malay in her teaching. She began her lessons by using formal English, to introduce the topics and the technical terms that she thought are important for the students to know and remember especially for the examination purposes. She started to use Malay and a mixture of English and Malay right from the beginning of the lessons, and continuously used English and Malay until the end of the lessons. Sometimes she translated from English to Malay or Malay to English, in different sentences, at other times she mixed English and Malay in the same sentence. Almost all sentences and words or terms in English were translated into Malay. Excerpts below demonstrate how Kalsom translated from English to Malay or vice versa, and used a mixture of English and Malay in various ways and situations.

Excerpt 1

1 T: OK seven-point-one, \(^4\) we will learn about Force \(\ldots\) F O R C E \(^5\) \(\ldots\) force. OK, can you tell me what is the meaning of force?

2 C: daya \(^6\) [force] \(^7\)

3 T: in Malay

4 T\&C: daya [force] (teacher together with students) \ldots force

\(^4\) “seven-point-one” referred to the number of the topic in the text book.

\(^5\) Capital letters were used to show that the teacher spelled the word.

\(^6\) Word or sentence in bold is word or sentence that is spoken in Malay.

\(^7\) Word or sentence in bracket [...] and is italic is the English translated version of the Malay word or sentence or vice versa.
5 T:  OK, what can you do when you have a force? Bila awak ada daya apa yang awak boleh buat? [When you have a force, what can you do?]

Symbols:

T:  Teacher
C:  Chorus answer8 (whole class)
Ss:  Several students
S:  Single student

Excerpt 1 demonstrates how Kalsom started to use Malay in her first lesson. At the beginning of the lesson, she introduced the topic in English. Then she asked the students about the meaning of “force”, and their answer was “daya” (Turn 2), which is the Malay term for “force”. The response given by the students was taken as a signal for Kalsom to start translating to Malay to ensure that they could understand her questions and explanation clearly.

The next example shows how Kalsom used a mixture of English and Malay in her teaching.

Excerpt 2

1 T  ... the example is the wooden block ya [yes], we just push or pull, tapi kita tak ubah, dia punya jisim dia tetap [but we didn’t change, the mass is still the same].

2 T  Ha ingat ni [Ha, remember], will not change the mass of an object.

(RSGKKTF1)

In Excerpt 2, Kalsom used English and Malay in one sentence. She changed her language from English to Malay in sentence 1, but moved from Malay to English in

---

8 Responding in chorus is a common phenomenon in Malaysian classroom, especially when the questions are not allocated to a particular student.
In the pre-lesson interview, Kalsom stated that she always begin a lesson with prepared notes in English, and switched to Malay when explaining a concept. She would asked the students if they understand her teaching in English, and when the students look puzzled, she would explained again in Malay. She considered the response that she received from the students as a cue for her to translate and use a mixture of English and Malay. Below is a quotation from her interview explaining the reasons to teach bilingually.

KALSOM  ⁹At first, in the classroom, I will give a note in English, then I use Malay in the process of explaining the specific terminology, the meaning of concept, for that purpose, I use more Malay. I speak in English at the beginning, and then I will ask the students if they can understand. When I see that they looked puzzle, I use Malay. The students usually answer “yes” but with the word “maybe” which indicates that they are not confident with their answer whether they understand or not. I don’t want that to happen to my students. I want them to fully understand the lesson. That is why I do the explanation in Malay.

(RSGKKII, 81)

She added that there were a few students who are good in English, but there were many others whose English was average or weak which made it unsuitable to use only English in her teaching. Personally, Kalsom preferred to use English in her teaching due to the fact that fewer words are used to explain science in English compared to explaining science in Malay. She thought that a science explanation in Malay requires a longer and more complicated sentence. Explanations in English are easier to understand, provided that the students’ comprehension of English is good. However, since the majority of the students in the class are from the villages neighbouring the school, their level of English was generally not at the level that is sufficient for them to fully understand the lesson if it is delivered in English.

If English is used exclusively, she believed that it could double the effort of learning science, since science by itself is already a difficult subject. The students then have to face the challenge of understanding English, and at the same time understand science.

⁹ All interviews were conducted bilingually (Malay and English) and were transcribed verbatim. However, all quotations used in this thesis have been translated to English and the original English words used by the interviewees were written in Italics.
She thought that with the culture of ‘shyness’ to ask question publicly in the classroom, it would be difficult for the students to learn science meaningfully.

Another reason for Kalsom to use Malay or a mixture of English and Malay was the changes of the language of instruction policy in 2012. According to her, many science teachers at her school were already using Malay in their teaching as a preparation for the changes. At the same time, the students were allowed by the school to use Malay or a mixture of English and Malay in their answers during tests and examinations.

Apart from using spoken language, Kalsom’s teaching was mediated by multimodal representations. Notes prepared beforehand on the white board were her main reference, as well as other types of representation such as a CD-ROM, objects such as wooden block, plasticine, and a ping pong ball and her drawings on the board. In an effort to discuss the topic with her students, Kalsom used and referred to the different representations mentioned above and most interestingly, she used a lot of hand gestures while explaining.

The part which is in brackets, and is _italic_ and **bold** in Excerpt 3, 4 and 5 below, demonstrate how Kalsom used multiple representations in her teaching. The example given in Excerpt 3 (Turn 1) shows Kalsom read word by word of the notes that she prepared on the white board, or sometimes drew some pictures on the board (as shown in Excerpt 4), in order to describe the topic, or to support her explanation. At the same time, she used various objects, such as wooden block (as seen in Excerpt 5) and plasticine, to demonstrate some aspects of topic discussed. Apart from that, Kalsom used a lot of hand gesturing while explaining, for instance as shown in Excerpt 3 (Turn 2 and 3) where she demonstrated the sign of “push” and “pull” by using her hand.

**Excerpt 3**

1 T Force ... OK, page fifty-eight ... OK look a note in front of you *(reading the notes on the board)*[^10] ... OK force is a pull or of push of an object ... _daya adalah satu push_ ... _apa_ push? *(force is a push ... what is push?)*

[^10]: Word or sentence in brackets, and is **bold** and _italic_ is additional information of the context.
Turn 3 in Excerpt 3 is one of the many other examples of Kalsom using her hands to mediate her explanation on describing “force”. In this particular example, she demonstrated “pull” with her hand before asking the students of the meaning of the word “pull”. The ways in which she used hand gesturing seem to be one of the strategies in helping the students to understand the language of instruction.

Excerpt 4

1 T OK ... Drogbar and Zinedin playing a football at the field...Drogbar pass the ball to the Zinedin...ha Zinedin ya ... katakan Drogbar [let say Drogbar] ... mana saya punya marker pen ya [where is my marker pen] ... ha Drogbar... ha ni Drogbar ya [ha this is Drogbar] (drawing a picture of Drogbar on the white board) ... ha Drogbar ... ha ini kerinting-kerinting sikit, Zinedin [ha this curly hair is Zinedin] (drawing the picture of Zinedin on the white board) ...OK ... pass the ball to Drogbar ...

Another form of representation used by Kalsom involved drawing some pictures on the board, as a tool for making her explanation clear. Sometimes she drew pictures of football players (as seen in Excerpt 4), in order for her to demonstrate how force is needed to stop an object. In Excerpt 5, Kalsom used a wooden block to show the impact of applying force to an object in a different direction. Such demonstrations are considered good strategies to provide a deeper understanding to the students.

Excerpt 5

1 T For the example, I push the wooden block (she pushes a wooden block she has positioned on the bench in full view of the class). Push. It
moving upwards. **Ia bergerak ke depan** [*it moves forward*]. When I pull (**pulling the wooden block**), what happen to the wooden block?

| 2 | Ss | Backward |
| 3 | T  | It moving backward. |

(rgkkktf1)

_The Students’ Language_

Students in this class used both Malay and English to respond to their teacher’s questions, but used mostly Malay in their discussions with their group members during group work. The pattern of interaction that occurred between the teacher and the students was usually teacher-centred, where the teacher asked questions and the students answered individually or as a whole class. The language that the students used to ask the question depended on the teacher’s language. If the teacher asked in English, mostly they gave their answer in English and if the teacher asked in Malay, they responded in Malay. However, there were times where the students gave their response in Malay for questions given in English, or responded in English when the teacher asked in Malay, as seen in the excerpts below.

**Excerpt 6**

1 T OK, what is the meaning of gravitational force?
2 Ss **Daya graviti** [*gravitational force*]

(RSGKKSF2)

**Excerpt 7**

1 T What are the effects of force? What are the effects of force? ...
   **Apakah kesan daya?** [*What are the effects of force?*]
2 C Change the direction

(RSGKKSF2)

Excerpt 6 shows that students gave their answer in Malay when the teacher asked in English. This type of conversation happened many times in this class where the
students tend to give the Malay meaning of the terms that were asked by the teacher. However, Excerpt 7 shows the students gave their answer in English when the teacher asked in Malay. In this case, the teacher had translated her question in Malay but originally asked them twice in English. Students might have been influenced by the English question that made them give their answer in English.

In group work discussion, the students used mainly Malay with some English. Since this class consists of Malay students, other ethnic languages were not used. A very minimal set of English words was used, such as the word “push”, “numbers”, and the name of specific equipment used in their experiments, for instance “spring balance”.

**Summary of Language Used in Kalsom’s Class**

Kalsom used English and Malay frequently and extensively in both lessons. Translating and paraphrasing was her common practice to ensure the students’ understanding, and perhaps also to cope with her own lack of competence in English. Kalsom used many multimodal representations too, as a teaching strategy in helping students understand.

**5.2.2 Hasnah Ahmad (science teacher)**

Another Malay female teacher involved in this research was Hasnah, who was trained to teach Science in Malay. With Science as her specialization, she was posted to teach at School R since graduating 13 years ago. She was schooled in Malay at every level; primary, secondary and tertiary level, however she had attended the in-service course, ETeMS, and was involved in the school’s in-house training, associated with the courses offered to Science and Mathematics teachers to teach in English. Her English she regarded as “average”, but she felt it was sufficient for her to teach Science in English.

*Hasnah’s Lesson*

Only one lesson from Hasnah’s class was recorded due to her packed timetable that did not allow the second recording to be done. The class was a “weak” class, which
Hasnah considered as weak both academically and attitudinally. This class was ranked at number 8 out of ten. It comprised only Malay and Indian students. Several times she mentioned that the students’ attitudes were bad, and that this was the main factor that hindered them from improving academically. Both their Science and English were also evaluated by Hasnah as “weak”. The lesson was about “Stability”, and the students were assigned to do an experiment in groups.

Summary of Hasnah’s Lesson

Lesson 1 – Stability

Hasnah starts her lesson by asking students the meaning of “stability”. She continues with showing a CD-ROM about “stability”. The CD-ROM plays for two to three minutes, explaining about “the centre of the equilibrium”.

Then Hasnah discusses the content of the CD-ROM that she has played, which the students could not understand. The discussion starts from the meaning of “stability”, and then followed by the teacher showing the CD-ROM again.

Next she discusses about “regular” and “irregular” shape with the students, before asking the students to refer to their textbook, to read about an experiment that they are going to conduct subsequently.

Firstly, she demonstrates the experiment in front of the whole class, and then she assigns the students to do the same experiment in their group.

The students do the experiment in their group, and Hasnah goes to each group to check on their experiment.

Then, Hasnah plays the CD-ROM which discusses the conclusion of today’s topic, before ending the lesson with revision of the topic that they have learnt today.
English and Malay were the language used in Hasnah’s teaching. It is interesting that she used more English than Malay to teach Science in a class that she considered as “weak” in both Science and English. Hasnah began the lesson by introducing the topic “Stability” and asked the students whether they knew the meaning of the word “stability”. All this was done in English. She repeated her question for the third time until the students responded “yes” which was followed by Hasnah asking them the meaning of “stability”. The students’ answer was “kestabilan”, which is the Malay term for “stability”. Then she continued with showing a CD-ROM about “the centre of the equilibrium”, and without pausing the CD-ROM gave some explanation, or at least rephrased some of the concepts discussed, since the CD player was malfunctioning. As a result, she just showed the CD-ROM for a few minutes and afterwards had a very short discussion about the content shown in the CD-ROM.

When she asked the students whether they understood the meaning of “stability”, she received a poor response from them. The students responded “yes” after Hasnah repeated her question several times. Then she asked one male student to explain his understanding about “the centre of the gravity”, but the student did not give any answer. From that incident, Hasnah started to use a few Malay words and sentences, such as “sediakala” (original), “kebolehan” (ability), and “keupayaan untuk mengekalkan kedudukannya yang asal” (the ability to maintain its original position), in her effort to explain the meaning of “stability” to the students. At the beginning, she only used a few words in Malay, but increased the Malay language into sentences, as well as used a mixture of English and Malay in a same sentence at a later time.

Excerpt 8

<table>
<thead>
<tr>
<th></th>
<th>T</th>
<th>OK student, today I will teach you about the stability. You know about the stability? What is the stability?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>C</td>
<td>...</td>
</tr>
<tr>
<td>3</td>
<td>T</td>
<td>Student, you know about the stability?</td>
</tr>
<tr>
<td>4</td>
<td>C</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>T</td>
<td>What is stability?</td>
</tr>
<tr>
<td>6</td>
<td>Ss</td>
<td>Kestabilan [stability] ... stabil [stable]</td>
</tr>
</tbody>
</table>
Excerpt 8 demonstrates how Hasnah introduced her lesson with asking the students if they knew “what is stability?”. She received no answer at the beginning, but the students responded when she repeated her question. Their answer was “kestabilan”, which is the Malay term for “stability”. The question “what is stability” might mean that the teacher was asking about the definition of “stability”, but yet the students gave her the translated version of the term. The students’ response indicated that they might think that the teacher asked for the Malay term of “stability”, or they might not know the meaning of “stability”. At this early point, it is becoming clear that the language used has created some confusion whereby a simple question asked by the teacher was misunderstood by the students.

Another interesting aspect of her teaching was that she received several requests from her students to change her English to Malay, due to them being unable to understand her teaching in English. She was aware of the situation, as well as the demand that she received from her students in regard to her language choice, but yet she still continued using almost fully English until the end of the lesson. Translation and mixing languages were the strategies employed by Hasnah to ensure students’ comprehension of the lesson.

One of the reasons for Hasnah continuing to use English in her teaching, which she mentioned in the post-lesson interview, was to familiarize the students with English terms since their textbooks were all in English. Furthermore, other resources such as CD-ROM provided by the government, and written notes were in English also. Even though the students were allowed to use Malay in their written examinations and tests, they were still required to use English in their written notes and homework. Therefore, she believed the students need to be exposed with English environment to encourage them to use and understand the language. As Hasnah explained:

HASNAH Everything is indeed in English, however when we teach, we explain. From my observation, there are some teachers
who use Malay exclusively in their teaching. I have never done that, I teach in English even to the students in the bottom class.

(RSBHAI2)

Hasnah added that she wrote all notes in English, but gave the explanation in Malay. Sometimes she underlined the specific English words that were difficult for the students to understand, and wrote the Malay translation for them.

Another conversation below shows that the students were faced with difficulties comprehending the teacher’s language of instruction.

**Excerpt 9**

1. T OK student, number one, how can you determine the point of equilibrium irregular and regular shape. You know what is the regular shape?
2. Ss No
3. T You know what is the regular shape?
4. Ss No
5. T OK this book, is this a regular or irregular shape? This one, regular or irregular?
6. C ...
7. T This one, regular or irregular?
8. C ...
10. Ss Sekata [regular]
11. T Sekata [regular]. Irregular?
12. Ss Tak sekata [Irregular]
13. T Bentuk tidak sekata [Irregular shape]
14. Ss Sekata [Regular]
15. T OK ... you see this one, is it the irregular or regular?
16. Ss Irregular
In Excerpt 9, the teacher asked whether they know the meaning of “regular shape” and they answered “no” twice. Then the teacher continued by showing them a book to ensure if they could determine the shape of the book, whether it is regular or irregular shape. She asked several times but did not hear any response from the students, until she translated the word “shape” to “bentuk” in Malay (Turn 5). The students then answered “sekata”, which is “regular” (Turn 6). Like the previous example in Excerpt 8, this excerpt also shows that the teacher’s language was one of the main factors that delayed the students’ understanding of the topic.

In this lesson, Hasnah used multiple representations such as the board, CD-ROM, and text book to assist her teaching. She wrote some important notes on the board, referring to the textbook for definition of concepts and displaying the CD-ROM in front of the class while doing her explanation. At some points, she showed the students a few objects such as a book, to help her explain certain concepts (as seen in Excerpt 9 to explain the meaning of regular and irregular shape).

*The Students’ Language*

Students in Hasnah’s class were only of Malay and Indian ethnicity, and they used Malay almost fully in their conversation. They sometimes responded to Hasnah’s questions in English, but restricted to one word chorus answers only, and mainly repeating the word that the teacher had said. Examples of the English words used were “regular” and “irregular”. Conversation between them was also mainly in Malay, except for some of the Indian students who sometimes used Tamil to talk amongst themselves.

*Summary of Language Used in Hasnah’s Class*

Hasnah used mainly English, with some translation, a mixture of English and Malay, and Malay language to deliver her lesson. She maintained the use of English as the main language, although some of the students requested that she use Malay.
5.2.3 Zila Rahim (mathematics teacher)

Zila is the youngest teacher who participated in this research, with less than a year of teaching experience. She is ethnic Malay, freshly graduated from a local university in 2009. Her teaching specialization was Information Technology (major) and Mathematics (minor). Her own schooling was in Malay, but she was initially trained to teach Mathematics in English. She considered her English as “average”.

Zila’s Lessons

The two lessons involved in this research were about statistics. Zila introduced the topic “Statistics” in the first lesson, and continued with “Frequency Tables” in the second lesson. Among her aims for these two lessons were to introduce the meaning of statistics, and to teach them about counting a set of data. She used the whiteboard to write notes and exercises for the students, while the students used their textbook as a reference, and did their exercises in their exercise book.

When asked about the students’ level of mathematics, she said that it was difficult for her to rate their mathematics level, since this particular class was the only Year 8 mathematics class she taught in 2010. However, if compared to the bottom classes that she taught from other levels, for instance Year 7, she found this class’ mathematics level was “good to average”. Based on their responses to her questions, she thought that the students could understand her teaching without many difficulties. They would ask or tell her if they had problems in understanding certain topics, or needed more explanation about their lessons. Therefore, she would only repeat the specific part that was problematic to the students.

With regard to English, Zila thought that the students could understand English well. However, when they were faced with difficulties understanding her teaching in English, they would ask her to repeat the explanation in Malay. She agreed that repeating the difficult aspects of the lesson was best if done in their first language. She believed the students could have more grasp of the content if she used Malay, rather than English. Besides, using Malay can help maintain the students’ interest in learning mathematics. Her thought was that students might “get lost”, and lose interest
Zila begins the lesson with writing the topic, Statistics, on the white board. Then, students are assigned to copy the exercises that she would write on the board, in their exercise book. She reminds some of the students that have forgotten to bring their exercise book, to do their exercises in a piece of paper, and paste it in their exercise book.

She writes the meaning of “classify data” (counted data and measured data) on the board.

Then, students are given the first exercise, which is to classify data by completing a table on the board, in order to determine whether the data is counted or measured data.

Next, she begins to explain the topic, and discusses the meaning of counted and measured data. The students are asked to do their exercise individually, and she walks around to look at the students’ work. Afterwards, she discusses the answers to the exercises with the whole class.

Then she introduces three methods to count or measure data, which are; to make an observation, to interview people, and to use questionnaires. She gives some examples of each method.

Later, the lesson continues with Zila writing a note on the board, about the three methods to collect and record data systematically, followed by a short explanation about them.
Lesson 2 – Frequency Tables

The lesson starts with the teacher asking the students whether they know the difference between “frequency table” and “tally table”. She writes the definition of “frequency table” on the white board, followed by examples of a frequency table, in a row form and in a column form. Students are asked to copy the tables on the board into their exercise book.

By referring to the notes written on the board, Zila explains the meaning of “frequency table”, and discusses its function. She revises the previous lesson by comparing “tally table” and “frequency table”, in which the frequency table uses number instead of “tally” for tally table.

Then, she gives the students other exercises which they need to do as group work, and the answers are discussed with the whole class after the students complete their task.

At the end of the lesson, Zila gives the students homework.
The Teacher’s Language

In both lessons, Zila relied on a mixture of Malay and English to deliver the content as well as to interact with her students. Malay was used largely to explain the key concepts of the topics, while English was used mainly for the technical terms of the topics. In most situations, she mixed Malay and English in one sentence. She maintained the technical terms in English, for example “counted data”, “measured data”, “frequency tables” and “tally tables”, without translating them to the Malay term, even when she used Malay to explain some concepts. However, in some parts of her explanation, she used “kekerapan”, a Malay term for “frequency”, without telling the students that it is a Malay term for “frequency”. An example can be seen in Excerpt 10.

Excerpt 10

1 T ... So hari ni kita akan belajar tajuk [today we are going to learn the topic of] frequency table. Hari tu kita belajar [The other day we have learnt] tally tables kan? [right?] Kalau [If] tally table dia ada yang [it has the] tally dia kan [right] ... betul tak [is it right] ... yang garis-garis kecil tu betul tak? [the small lines right?] Kalau untuk [If for] frequency table, kita tak perlu, kita tak perlu ada [we do not need, we do not need to have] tally. Just kena ada yang [need to have] number untuk [for] frequency ini [this]. OK, sekarang ni kita nak tahu [now we want to know], apa [what is the] function frequency tables ni. OK firstly dia apa [it] ... dia nak ... [it] shows the number of times and events occurred (teacher read from notes written on the board). OK maksudnya kat sini, contohnya [here it means ... for example] ... faham tak apa maksud dia kat sini? [do you understand the meaning here?] Shows the number of time, faham tak?[understand?]

2 Ss faham [understand] ... tak faham ... [don't understand] (some students responded “understand” while some others responded “don’t understand” simultaneously)

3 T Faham tak? [Understand?] OK maksudnya kat sini dia nak tunjukkan, berapa kali atau kekerapan sesuatu peristiwa tu berlaku, faham? [the meaning here is that it shows how many times, or frequency of an event occurred, understand?] OK contohnya macam dekat sini, peristiwa kita yang berlaku adalah fasal [for example, our event is about] career chosen, maksudnya [which means] career atau pekerjaan yang dipilih [or the chosen job] ... OK pekerjaan yang dipilih [the chosen job]. Dekat sini ada [here we have] lawyer, doctor, teacher,
In Excerpt 10, Zila began her explanation of “frequency table” by comparing it with “tally table”, which the students had learned in the previous lesson. She described the function of “frequency table” based on the notes written on the board. Her explanation was nearly all in Malay, except for technical terms in mathematics, such as “frequency table”, and the career names from the example table that she wrote on the board, for example “lawyer” and “policeman”. This excerpt shows one of many ways in which Zila inserted English terms in her Malay sentences, freely. No specific rules were used in choosing the language, except that she used the languages in a way that she thought could make her students understand the topic clearly.

**ZILA**

For me, I use English because I have to, since the textbook is in English. If I use Malay exclusively, the students would have difficulties to understand the textbook, which would effect on them not to be able to do the exercise given. However, if I use a lot of English in my teaching, firstly the students would feel uncomfortable, secondly, if they could not understand English, if from the beginning they do not understand, they will be uninterested to ask a question later. So, even though their understanding is not hundred percent, at least if they can understand for 70 percent of the lesson, they should still have the interest to learn.

(RMGZRTII, 76)

Since she considered the students’ level of English as “good to average”, she translated only difficult words or sentences, and avoided the word-by-word translation. This is evident in Turn 1, where she translated the whole sentence of “... shows the number of times and events occurred” to Malay, maybe for the reason that it was crucial for the students to fully understand of the concept. On the other hand,
she just used “lawyer”, “policeman” and “career” in Turn 3, since those are simple words that the students should understand easily.

Malay was also used in her interaction with her students. She had a few Malay informal interactions outside the topics, which she explained in the interview as a way to avoid tension among the students.

In her teaching, Zila depended heavily on the whiteboard as a medium for her to prepare notes and exercises for the students. Students on the other hand, used their textbook as a main reference for the topics discussed. Both lessons showed Zila used many tables to give examples and exercises on “counted data”, “measured data”, as well as the “frequency tables”. Most of the time, she explained the tables column by column, and guided the students to the correct way of expanding the tables with more data. Counting using “tally” also required her to show a step by step procedure on the board.

The Students’ Language

The students in this class used Malay exclusively. They conversed amongst themselves in Malay, but most of the time followed the teacher’s language when responding to the teacher’s questions. If their teacher asked in Malay, they answered in Malay, and if the questions were in English, they gave their answers in English. According to the teacher, the students who are ethnic Malay, felt more comfortable to use Malay to learn Mathematics. She found that some of the students were weak in communication in English, but some others were weak in writing. However, students who were weak in writing faced only a minor problem in learning mathematics in English since to her, writing is not a very important aspect in mathematics. She believed that the students could always use the information in the questions to construct their answer. The most important thing to her was for the students to give a correct answer. Therefore, her concern was more towards the students’ spoken language, which she thought needed to be improved.
Summary of Language Used in Zila’s Class

In general, spoken language was dominant in both of Zila’s lessons. However, written, and visual forms such as tables, played important roles too, in providing the students with different forms of information. As a way to help the students integrate the different forms of information given, Zila employed a strategy of using Malay and English in her explanation. She mixed the languages freely, as flexible as it could be as long as the students could understand. Since the written forms were all in English, she used translation and a mixture with Malay in her spoken communication, in order to ensure students understood the ideas.

5.2.4 Bo Yang (mathematics teacher)

Bo is a female Chinese teacher who has been teaching for 14 years. She began her career as a primary teacher in 1994 with a teaching specialization of Mandarin. She further studied at a local university and graduated in 2008 with Mathematics as her teaching option. After graduating, she was posted to a secondary school in Melaka City, and transferred to School R in the same year.

Bo thought her English was just “average”. She taught Mandarin at a Chinese secondary school for ten years, where Mandarin was used exclusively except for two subjects, Malay and English. At the university where she did her bachelor degree, the lecturers used a mixture of English and Malay. Bo said that the lack of an English environment in her education and career background, as well as in her daily life made it feel awkward to use English, especially as a spoken language.

Bo’s Lessons

The two mathematics lessons recorded from Bo’s class were about two different topics, Reflection and Surface Area. The class was considered as a medium Year 8 class, ranked number 6 out of ten. She rated the students as “weak” in both their English and Mathematics. She thought that the majority of the students, particularly the boys, have little interest in learning mathematics, and sometimes she felt frustrated with the situation.
She considered the students’ English as “weak” based on her experience of using English in her teaching. Most of the students could not understand her when she used English, which made her change to Malay. She thought that the students were more comfortable to learn in Malay. They preferred to use Malay in their tests and examinations too. At the same time, the school’s mathematics sector encouraged the teachers to prepare their tests and examinations questions bilingually, especially in the effort to help the students from the weak classes to achieve a better result.

Summary of Bo’ Lessons

Lesson 1 – Reflection

Bo begins the lesson by writing the term “reflection” on the board, and asks the students if any of them know the Malay term for “reflection”.

She prepared a few drawings that she pastes on the board, as a reference while giving her explanations. The first drawing is a picture of a triangle, with three different images for students to select as the correct reflection of the triangle. The second drawing shows a triangle with its image, in which she discusses the “axis of reflection”. The third drawing contains a list of the properties of reflections.

Bo then divides the students into five groups and assigns them an activity for group work. Each group is given a piece of paper, which already has a picture of an object and the “axis of reflection” on it. The assignment is to draw the correct image of the object.

After completing their task, each group pastes their work on the board, and the teacher discusses the answers for each exercise with the whole class.

Before finishing the lesson, Bo gives the students an exercise on the topic of “reflection” as homework.
Lesson 2 – Surface Area

The lesson starts with Bo revising the names of different solids that the students had learnt in their previous lesson.

She writes the definition of “surface area” on the board, and then pastes a piece of paper which has a drawing of a prism, on the board. She guides the students to calculate the surface area of the prism by drawing the net of the prism.

She discusses calculating the surface area of three other prisms and a pyramid, by using the method above.

The students are then divided into five groups and are given an exercise that involves finding the surface area of a solid whose net is already prepared on a piece of paper. Each group receives a picture of a different solid. They work in their groups and the teacher goes from one group to another to check on their work.

Next, each group puts their work on the board, and the teacher discusses their answer with the whole class.

The students were then asked to do some exercises from their textbook as homework.

The Teacher’s Language

In both lessons, Bo used a mixture of English and Malay. However, she used more English in the second lesson than the first lesson. She began the first lesson in English, and then she moved from English to Malay back and forth. She did some translation, but the translation was not using a word to word translation. Sometimes, she explained the English written notes in Malay. For example, she described the “properties of reflection” in Malay, while the notes were written in English.

As mentioned earlier, Bo used more English in the second lesson. She started the lesson by writing the definition of the topic, “Surface Area”, on the board, while at the same time saying aloud the words that she was writing. Then she explained the
definition written on the board in Malay, before continuing her explanation in English. She discussed with the students the “step by step” method to calculate the surface area of four solids, predominantly in English. This situation can be seen in Excerpt 11.

**Excerpt 11**

1 T Surface area is the total area of all the faces of the solid, or we also can say that the area of net of the solid. That means, surface area ni ialah jumlah permukaan [is the total faces] area bagi satu [for a] solid. Boleh faham? [Understand?]

(RMMBYTF2)

The example above (Excerpt 11) shows that Bo gave a simple Malay translation for her English definition of “surface area”. The second part of the definition, which is about the “net” of the solid, is not translated into Malay. She provided the students with only the basic meaning of “surface area” in Malay, that is “the total faces of a solid”.

Another example in Excerpt 12 shows Bo used a mixture of English and Malay when discussing the calculation of the surface area with her students. This excerpt was taken from an episode where Bo calculating the surface area of a trapezium, together with the students. She prepared a picture of a trapezium on white paper, pasted it on the board, and showed the students the step-by-step method of calculating the surface area. She had an active discussion with them while doing the calculation on the board. In regard to the language used, Bo moved from English to Malay, back and forth, in her effort to teach them of the surface area calculation. However, she maintained her use of English for most of the technical terms, such as “triangle”, “angle”, “rectangle”, “net”, “base”, and “area”.

**Excerpt 12**

1 T OK firstly, what we need to do?
2 Ss Kita letak label a, b, c [We put the label a, b, c]
3 T The net. OK this one is the net. OK this one is the base (while colouring the base area). So, this one is six, nine, OK continue with this one?
4 Ss Triangle
In teaching with multimodal, Bo used the white board as her main medium to show and discuss the calculation with her students. At the same time, she also prepared some drawings that she pasted on the board to assist her explanation. She was the only teacher that prepared students’ exercises on white paper and assigned them to complete the exercise on that piece of paper before pasting it on the board and discussing the answers with the whole class. During discussions, Bo guided her students in doing the calculation based on the pictures of different solids that she pasted on the board. She switched between Malay and English, explaining and asking students and at the same time writing and pointing at the spots that were being discussed.

*The Students’ Language*

Students in Bo’s class used Malay and English in their conversation. During discussion with the teacher as a whole class, the students gave their response to Bo’s questions in English and Malay. However, they used nearly fully Malay in their group discussion. The data showed that the students used only the measurements unit, which is “c m square” (sic), and a number of words, such as “total” and “times”, in English. In regard to languages of other ethnic groups, there was no example where students from ethnic Chinese and Indian used their first language during their group work. However, in the interview, Bo said that sometimes the Chinese students used Mandarin, and the Indian students used Tamil to communicate with their friends from the same ethnic group.
Summary of Language Used in Bo’s Class

Bo and her students used both English and Malay in both of the lessons, while students interacted with their peers mostly in Malay. As a coping strategy, Bo employed a few common strategies that are used in bilingual classrooms, such as translation, mixing languages, or using the national language to explain, discuss and ask questions to the students.

5.2.5 Anis Mahmud (science teacher)

Anis has been teaching at School U for three years, with five years of overall teaching experience. She was one of two female Malay teachers participating in this research, with Malay as her first language. Graduated from a local university, her teaching specializations were Chemistry (major) and Health Education (minor). When asked to rate her English competency, she claimed that her English was “average”, by which she meant being a fluent English speaker, yet lacking in vocabulary. For the purpose of teaching, she found it manageable even though her English competency was just average. One of the reasons why it was manageable was that texts and text books in English had already been prepared and were ready to be used.

Anis’ Lessons

Nutrition (L1) and Calorific Value (L2) were the topics in Anis’ class. The class was a Religious Stream Class, which was considered as a “good” class, the second ranked out of 14. The students were all from the Malay ethnic group. According to Anis, religious stream students were usually quiet in the classroom, and not very active in asking questions, particularly in front of other students. They were rated “average” in both Science and English.
Summary of Anis’ Lessons

Lesson 1 – Food Test

The teacher informs the class of the topic for the day which is “Food Test”. She begins by having some revision of the number of food classes that the students had already learnt. The teacher asks specific students to tell the whole class about the seven classes of food: carbohydrate, protein, vitamins, fat, minerals, fibre and water.

Then she tells the whole class that they are going to carry out experiments for food testing. The students are asked to refer to their textbook, which contained all the procedures needing to be taken for conducting the experiments. She called upon a group leader of each group to collect apparatus for conducting the experiments.

She reads aloud and explains the procedures that the students need to follow, which is written in the textbook. Then she demonstrates the experiment of protein test at one of the students’ table, and asked all students to watch. Later, each group conducts their food testing experiments until they completed all the seven classes of food.

When the students finish their experiments, they are asked to clean all used apparatus, and then to complete an exercise from their textbook. They are given ten minutes to complete their work, and Anis discusses it with them later.

The lesson continues with the teacher discussing the answers of the exercise given with the whole class, before concluding with some revision of the topic.

Lesson 2 – Calorific Value

By referring to notes in the textbook, the teacher explains about calorific value. It follows with her showing an example on the board
of calculating the calorific value of selected food.

Then the teacher asks the students to calculate their lunch’s calorific value, and discuss it with their group members. While doing their calculation, the teacher goes from one group to another to help the students with their work.

When they completed their task, the teacher calls two students to write down their lunch’s calorific value calculation on the board, and at the same time discusses it with the whole class. Then they continue to discuss some exercises in their text book, before the teacher ends the lesson.

The Teacher’s Language

Generally, Anis used both English and Malay to deliver her lessons. In the first lesson which was done in a science lab, she maintained the use of English almost exclusively, except for some private interactions with some of the students in their group. On the other hand, Anis used more Malay in her second lesson, which was held in a classroom. In the lesson in the lab, the students were assigned to do a number of experiments for food testing. They conducted seven tests, and had a discussion at the end of the lesson. While in the second lesson, they did some calculation to find out the calorific value of their lunch.

In particular, Anis used English to talk to the whole class, but sometimes responded in Malay to some questions asked in Malay. When she conversed in Malay, she spoke in a low voice and almost whispering, as if she tried to avoid using the language. However, she used a clear and loud voice when speaking in English.

On the other hand, Malay was used considerably in the second lesson as compared to the first one, even though English was still the main language used. She used Malay in her discussion with the students at the time when she went from one group to another to check on their work.

For the lesson in the lab, she used the text book as a reference, and students were assigned experiments which required them to deal with many kinds of lab apparatus.
From time to time, Anis checked their experiments, sometimes answering questions or showing them the right way of doing the experiments. In the second lesson, she referred to the exercises in the textbook and used the white board mainly to show them how calorific value of food was calculated.

*The Students’ Language*

Given the fact that all students are Malay, they used Malay and English to talk and communicate to each other or with the teacher. Excerpt 13 is one example of students’ conversation in the second lesson.

**Excerpt 13**

1. S1 What you want eat?
2. S2 I eat nasi lemak one plate, coffee one cup, and curry puff for two piece, for my lunch.
3. S1 Wow, your lunch!
4. S3 So many calory right?
5. S1 What you drink in lunch?
6. S2 Hmm ... I eat
7. S1 Nolah, drink ... maybe juice apple
8. S2 Juice ...
9. S1 Maybe orange juice?
10. S2 Watermelon, watermelon juice

(UGSAMSF2)

The conversation shows in Excerpt 13 occurred in a group discussion of female students on the topic of Calorific Value. They managed to use English almost exclusively, but the language used was basic with simple words and sentences, with some grammatical mistakes.
Summary of Language Used in Anis’ Class

Both languages were used in Anis’ class. She used mostly English to deliver her lessons, but sometimes talk in Malay with her students especially during their group work or individually. Students who were all Malay talked amongst them in Malay, but responded to their teacher in both English and Malay. Artefacts used were laboratory’s apparatus such as test tube, and Bunsen burner, and also the white board as a medium for her to show the calculation of calorific value in Lesson 2.

5.2.6 Beng Hong (science teacher)

Beng was the only male teacher participating in this research, an ethnic Chinese with Mandarin as his first language. He has 20 years teaching experience, and 2010 was the first year of him teaching at School U. His teaching specialization was Information Communication Technology. He believed that his English was “average”.

Beng’s Lessons

The topics in Beng’s class were Support System (L1) and Stability (L2). The class was ranked 7 out of 14. Beng considered the students in this class as passive. He believed that attitude was the main constraint for the students to become successful in their academic achievement. To him, if they had no interest in learning, any language used would make no difference to them. He judged both the students’ Science and English level as “weak to average”.

Summary of Beng’s Lessons

Lesson 1 – Support System

Beng commences the lesson with an explanation about muscle and skeleton. He reminds his students about support system which they need
to have a good understanding, followed by explaining the topic mainly by referring to notes in the textbook.

Then Beng shows some human and animal endoskeleton transparencies on the board, and explains aspects of these. He moves on to describe aquatic vertebrate support systems, also by using information in the textbook and a transparency on the board. Later, he shows a transparency of an exoskeleton and hydrostatic skeleton with some explanation.

After asking the students whether they have any question to ask, Beng introduces the next topic, which is the support system in plants. He reminds the students that they have already learnt about plants’ classification, woody and non-woody. He explains and shows pictures of buttress root, prop root, and clasping root.

Next, Beng gives the students an assignment which they need to complete with their group members in ten minutes. The question given is different between groups, based on the topic that they have learnt just now. Basically, every group needs to list down the names of the animals or plants of a particular group, according to the question given to them.

While all students are doing their work in their group, Beng goes from one group to another to discuss, answering questions, and helping them to complete their task. Then, every group submits their work to the teacher, and Beng concludes the lesson by revising the main concepts that the students have learnt on that day.

Lesson 2 – Stability

The lesson begins with the teacher explaining the meaning of stability. He read some of the notes in the textbook, besides asking the students about some concepts that are vital for them to understand, for instance the meaning of stable and unstable. Followed then is a description of “point of equilibrium”, which is also known
as “centre of gravity” of an object.

Beng demonstrates an example of finding the “points of equilibrium”, in which he tries to locate the points of equilibrium of a ruler, by putting the ruler on his hands. He tells them that they will conduct an experiment later.

Then Beng shows another experiment, which uses two wooden objects, shaped like a four legged animal, being put on a wooden tray that he slants slowly, in order to find out which object collapse first. He repeats the experiment several times due to it being unsuccessful. He then figures out that the failure has resulted from the different mass of both objects. Then he changes one of the objects, in an effort to get two objects with the same mass, and the experiment is successful.

Next, he calls upon the group leaders to collect all apparatus needed for their experiment, and the students begin their experiment in group. He takes this opportunity to interact with the students, and help them to accomplish their assignment. When they finish their experiments, the teacher asks them to pass up their work to him. Finally, the teacher concludes the lesson with revision of the topic.

*The Teacher's Language*

Interestingly, Beng used multiple languages in his teaching. He talked and conversed in English, Malay, and Mandarin, but maintained the use of English almost exclusively while giving explanations and descriptions at the beginning of the lesson. His students came from diverse ethnic backgrounds and so he used multiple languages to interact with them.

In both lessons, Beng seem to use English almost exclusively at the beginning of the lessons, in which he explained and described the main ideas of the topics. He switched to Malay in some parts when he tried to interact with the students, or to gain their attention. When giving instruction as well as interacting with them in their group
activity, Malay was used mainly, with a little of English and Mandarin, obviously in the second lesson.

During the explanation and description part at the start of the teaching in lesson one, Beng used English only. He used Malay for the first time when he asked the students whether they could understand the topic or if they have any questions. The dialogue can be seen in Excerpt 14.

**Excerpt 14**

<table>
<thead>
<tr>
<th>Turn</th>
<th>Role</th>
<th>Dialogue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>T</td>
<td>Siapa tak faham? [Who did not understand?] Ada soalan yang kita belajar tadi tu? [Is there any questions for what we have learnt just now?]</td>
</tr>
<tr>
<td>2</td>
<td>S</td>
<td>...</td>
</tr>
<tr>
<td>3</td>
<td>T</td>
<td>Ini bermakna, apa kita kata, sistem sokongan haiwan ini ada tiga jenislah. [It means that, there are three types of support system for animals.] Mereka adalah apa? [What are they?]</td>
</tr>
<tr>
<td>4</td>
<td>S</td>
<td>...</td>
</tr>
<tr>
<td>5</td>
<td>T</td>
<td>Endo ...</td>
</tr>
<tr>
<td>6</td>
<td>Ss</td>
<td>Skeleton</td>
</tr>
<tr>
<td>7</td>
<td>T</td>
<td>Exo ...</td>
</tr>
<tr>
<td>8</td>
<td>Ss</td>
<td>Skeleton</td>
</tr>
<tr>
<td>9</td>
<td>T</td>
<td>Skeleton, and</td>
</tr>
<tr>
<td>10</td>
<td>Ss</td>
<td>Hydrostatic skeleton</td>
</tr>
<tr>
<td>11</td>
<td>T</td>
<td>Hydrostatic skeleton</td>
</tr>
</tbody>
</table>

In Excerpt 14, Beng questioned the students, as well as summarizing the main idea of his teaching in Malay. Even though there was no answer in Turn 2 and 4, he continued to use Malay, probably to create a situation that could encourage the students to talk or respond. He explained the purpose of using the national language was to find out his students’ understanding, which was his common practice. If he asked in Malay, the students were more likely to respond than if he asked in English.
BENG That was such a strategy, where I used Malay to investigate their understanding, which they would respond ... If I asked in English, it was less effective, whereby they rarely gave their response in English. ... if I asked them in Malay, their response would be much better, since they could answer in Malay. So, I would know whether they understand or not.

Apart from using Malay to probe and ensure students’ understanding, he explained in Malay at the part which involved the meaning of words. Excerpt 15 shows how he differentiated between two words in English which have the same meaning in Malay.

**Excerpt 15**

1. T and then thorns and prickles, is different, OK you can see the difference, thorns are modified branch and it cannot be easily removed from the stem, but prickles is an outgrowth of the epidermis, and can be easily removed. That means the difference is, for thorns, is not easily for remove, but prickles is easy to remove. 

   "Tapi dalam bahasa Melayu masih lagi ada duri, yang berlainan adalah ... apa ... berlainan adalah apa ... dia punya duri, satu dia senang ... kita kata patah ke, atau dicabut ke, kalau senang punya kita kata prickles lah [But in Malay, they are called “duri”, the difference is ... what ... the difference is ... its “duri”, one is easy ... we called it broken, or pull out, the easier one we called it prickles]. OK example like ... rose, rose ... is prickles. Thorns like ..."

2. Ss Bougainvillea

3. T Ha ... Bougainvillea

The Malay language was purposely used to explain the same Malay word which referred to two different words in English. “Duri” is the meaning of both “thorn” and “prickle” in Malay. Beng tried to clarify the difference between the two words in the language that he considered more comprehensible to the students. He saw it as an effort to prevent any confusion that might occur as a result of learning bilingually.

At some points of his teaching, Beng did some translation from English to Malay in order to paraphrase his explanation. For this purpose, Beng seemed to insert the Malay translation into his English sentences, specifically at the part where he assumed it was vital for the students to understand. He rarely did a word-by-word translation. An example can be seen in Excerpt 16.
Excerpt 16

T OK here got some sort of additional support [lah], ini kita panggil apa? [What do we call this?] Tambahanlah, dia kata, sokongan tambahan. [Additional, it is an additional support]. OK like buttress root, the tap root system of large trees does not provide good support, because the tree is very big, so many of these large big trees have buttress root at the base of the stem to provide of what we called ... to provide extra support. For example, durian trees ...

(USMBHTF1)

Excerpt 16 demonstrates how Beng inserted Malay phrases into his English sentence. He translated the phrase “additional support” as it was considered an important concept in the support system. The rest of the sentences were articulated in English, in which he gave further information and examples.

Meanwhile, in his interaction with the students, Beng used English, Malay, and Mandarin, most likely depending on the receptive ability of the students. Generally, he used English and Malay in his conversation with them. Particularly, he used Malay with many of the Malay students, English with a few of the Malay, many of the Chinese and the two Indian boys (the only Indians in the class), and Mandarin with a few Chinese students, only when they asked in Mandarin.

In respect to multimodality, apart from the verbal and nonverbal language, Beng employed multiple representations to assist his teaching. There was a text book as a main reference, transparencies displayed on the board, and objects such as ruler and blocks, as part of the materials used. In the meantime, he assigned the students to draw a table to classify human’s and animal’s support systems (Lesson 1), and doing an experiment to find the points of equilibrium of an irregular shape in Lesson 2, which required the students to deal with a number of materials (card board, thread, scissors).

Together with his explanation and description of the topic in the first lesson, Beng referred to the notes in the textbook, as well as the pictures displayed on the board. He moved from the notes in the book to the pictures on the board back and forth while explaining. In the second lesson, he continued to refer to the notes in the text book,
together with demonstrating two experiments in front of the class, using ruler and wooden blocks.

**The Students’ Language**

Malay, English, and Mandarin were the languages used by students in Beng’s class. Compared to other students from all classes participating in this research, Beng’s students did the most of talking and discussion. In both of his lessons, Beng assigned the students to work in groups, which allowed them to have a lot of conversation and discussion with their teacher and friends. This reality could seem to contradict Beng’s statement in his interview where he claimed that the students were “passive in class”. However, Beng’s point of view was valid regarding students’ whole class response.

Malay was used by all students, particularly Malay students, during discussion with their group members, and interaction with the teacher. At the same time, English was used too, especially by the Chinese and Indians, and Mandarin was used by the Chinese to communicate amongst themselves. For instance, in a group consisting of all ethnic background students, they preferred to use Malay and English in their discussion. They maintained English words such as the name of the animals and plants, but used Malay to talk with each other more generally.

**Summary of Language Used in Beng’s Class**

In his class, Beng used English, Malay, and Mandarin as a language of instruction, and so did his students. English was used at the beginning of each lesson, while Malay and Mandarin were used during interaction with students. A very minimal amount of Malay was used during explanation for the purpose of translating or paraphrasing important concepts and ideas that were explained in English.

**5.2.7 Seow Chin (Mathematics Teacher)**

Seow Chin is a female teacher who is ethnic Chinese, with 31 years of teaching experience. She became a teacher in 1979, and has been teaching Year 8 classes since
then. Her teaching specialization was mathematics and she has been teaching at School U since 1987. Her own schooling was in English, as well as the in-service training. For that reason, she rated her English as “good”. Seow has had experience of teaching mathematics in both Malay and English. When asked whether there was any difference in teaching the subject in Malay and English, there was not much difference for her but she felt students were faced with understanding difficulties. One of the difficulties was the confusion of mathematical terminologies when the teaching was done bilingually. Sometimes the students were confused with the technical terms, when they could not match the English and the Malay terms. As a solution, she had to explain the meaning of a Malay term so students could match it with the English term.

**Seow’s Lessons**

The two lessons were about Solid Geometry and Surface Area. Seow’s class was a good class which was ranked one out of fourteen. Compared to other Year 8 classes at that school, Seow considered their mathematics level as “very good” but rated their English as “average”. Most likely, they could understand the language but lacked confidence in speaking. The class consisted of 31 students from ethnic Chinese, Malay, and one Indian student. She described them as “a bit shy to ask questions in class”. They would come to her individually if they needed further explanation (UMGSCI1). Since a majority of the students were Chinese, Seow believed that part of the reason was the Chinese school’s culture, where the students were more serious in learning and preferred to work on their own.

**Summary of Seow’s Lessons**

**Lesson 1 – Solid Geometry**

Seow begins the lesson with calling all the group leaders to collect a paper bag from her. Then, she assigns the students to take out the things in the bag, which are different geometric solids (pyramid, prism, cone, sphere and cylinder).
She reminds the students that they had learnt the topic, Geometric Solids, when they were in Year 7. She asks the students to observe the solids, to remember their names, then to look at a given form, and find out the geometric properties of the solids.

She read the instruction one by one, which involve counting the number of faces, edges, vertices, with the names of the given solids. Afterwards, they need to discuss the answers with their friends, and fill in the table. Then the students do their assignment, and the teacher goes from one group to another to check on their work.

Next, she asks the students to go to question number 3, which is to name the solids according to certain criteria. She compares their answers, and asks selected students to write their answers on the board. Then one group gives a different answer concerning if a cylinder has any edges or not. She discusses this and receives different answers from the students. She gives an example to explain the situation.

The discussion continues with the teacher asking selected students to give the answers, and compares the answers with other students’ answers. Next, the teacher asks the students to remove the sticky tape from the solids, and open up the solids to find out the net of the solids. Then students are asked to stick the net on the board, into the appropriate column that the teacher has prepared.

Afterwards, she asks the students to observe the nets of the solid. Even though the solids were the same, the nets were different. She shows the students, two other 3D solids, a cube and cuboids, and asks the students in which group those two solids can be grouped? The students give the correct answer, which is a prism. She then shows another solid, a trapezium.

Later, she assigns the students to draw their own nets in their exercise book. She distributes the exercise sheets to the students and they continue with the exercise.
Lesson 2 – Surface Area

The lesson begins with the teacher showing the students a cylinder, a cone and a sphere's 3D models, to discuss the solids' surfaces. All of the solids have curved surfaces.

A cylinder has a curved and two flat surfaces. The teacher asks one student to open up the solid and find out the net, in front of the class. She asks the student to remove the sticky tape and sticks it on the board.

Then she shows the students the net of the cylinder, which includes a rectangle (formula is length times breadth). The breadth is the same of the height of the cylinder. Then she asked the students the measurement of the length. The answer the students give is that the length is equal to the circumference of the circle. Afterwards, the teacher shows the formula to calculate the surface area for a cylinder, on the board.

Next, she discusses the formula for the surface area of a cone. She shows a 3D cone model, and then opens up the model to find out the net of the cone. She continues with showing the way of calculating the surface area on the board.

She opens up a cone, and pastes the net on the board to calculate the surface area of a cone. She uses terms such as “radius”, “arc”, “circumference”, “area of circle”, and “area of sector”, in showing her calculation to the students.

Then she discusses the formula, and stresses that every formula that they use in mathematics, has been proven and tested. She asks the students to refer to their textbook, and do the enrichment activity, which is to find out about Archimedes (a Greek mathematician).

She asks them to take out their exercise book, to work in their group, and find a surface area of the solids. She divides them into several groups, and asks them to complete exercises from the textbook.
When the students finish, she call upon a member of each group to present their answers on the board. Then she discusses it with the whole class.

Seow writes an exercise on the board and asks them to discuss it with their group members. Then she calls a few students to write their answer on the board, and discusses them with the whole class.

_The Teacher’s Language_

Seow was the only participating teacher from both schools who taught entirely in English, in both lessons. She began her first lesson with some activities for the students to do in their group. Each group was given a paper bag containing geometric solids, and exercise sheets to fill in as a basis of their discussion until the end of the lesson. She prepared a lot of exercises for the students to do and discuss, and the students had a lot of activities in their group.

In terms of multimodality in teaching, Seow used many types of artefacts in her lessons. In Lesson 1, she prepared different kinds of 3D solids for each group to use as the basis of their discussions. She discussed the properties of each solid by referring, showing and pointing to the 3D objects that were given to the students. She pointed at the vertices, edges and faces of those solids. The same 3D solids were also used to find the net of each solid. Some students were called to write the answers on the board, while others were asked to paste the nets of the solids on the board. In the second lesson, Seow continued the discussion about the nets of the solids by using the same artefacts she prepared in the previous lesson. Apart from that, white board was heavily used as a medium for comparing and discussing the answers of the exercises given to the students, as well as to paste the nets of the solids.

_The Students’ Language_

Malay students used English and some Malay, Chinese used English and Mandarin, and Indians used English exclusively in their interaction with their peers. However, they conversed with their teacher entirely in English. The students’ English level was
rated “average” by Seow but they seemed to understand the teaching without difficulty. They could respond to all questions asked by the teacher in English. Excerpt 17 is one example of the teacher’s talk with her students. This excerpt is taken from Seow’s discussion with the whole class when she showed them a few other 3D solids that were not included in the paper bag. She showed them a cube and a cuboid and asked them to guess the name of those solids based on their properties. She had a smooth exchange with the students which indicated that they understood the language well.

**Excerpt 17**

1  T  I have other solids here. Now, do you remember this? (Showing the students a 3D cube).
2  Ss  Yes.
3  T  What do you call this?
4  Ss  Cube.
5  T  A cube. OK a cube. What about this? (Showing them a cuboid)
6  Ss  Cuboid.
7  T  A cuboid. OK very good. Now these two, which group would you put them in? Prisms, pyramids, cones or cylinders?
8  Ss  Prism.
9  T  Good. A cuboid and a cube, they are also prisms. All right, why? Parallel faces that are polygon. Can you see or not? This is a polygon. This is also a polygon. Congruent and parallel to each other. So this is why this is also a prism. (Showing a trapezium) Prism or pyramid?
10  Ss  Some replied “pyramid” and some replied “prism”.
11  T  Prism. Why?
12  St  Both are the same.
13  T  Again because they have two polygons here. This is a trapezium.

(UMGSCFT1)

Even though almost all answers given by the students in Excerpt 17 was a one word answer (except in Turn 12), their prompt responds clearly demonstrated their ability to understand and give their reply in English.
Summary of Language Used in Seow’s Class

English was the language used by Seow either to deliver her lessons or communicate with her students. On the other hand, some of her Chinese students used Mandarin, while the Malays used Malay to talk amongst themselves. At the same time, she employed artefacts such as 3D solids, exercise sheets, textbook, and white board to assist her teaching.

5.2.8 Normah Ali (mathematics teacher)

Normah was another young female teacher who has been teaching for three years altogether, with 2 years of experience of teaching at School U. Her teaching specialization was Biology. She felt her English was “weak to average”, that she could communicate in “broken” English. Her pre-service program was supposed to be conducted in English, but it was done in Malay and English. In that program, some subjects were still being taught in Malay.

Normah’s Lessons

The lessons were about Rotation (Lesson 1) and Linear Equations (Lesson 2). The class was a medium class ranked at 7 out of 14. This class was considered “average” in both Mathematics and English. The students were Malay, Chinese and Indian. Normah described them as “talkative” with “lots of talking about subjects unrelated to the topic discussed” (UMMNHI1). She added that an attitude problem was obvious amongst the students, in which sometimes they refused to do extra exercises given, were unable to give their focus to learning, and tended to give a lot of excuses when they were given exercises or homework.

Summary of Normah’s Lessons

Lesson 1 – Rotation

Normah reminds her students about yesterday’s lesson, Reflection,
and relates it with today’s topic, Rotation. She explains the similarity of the two topics, which is “the movement from object to image”.

She asks them to refer to an exercise in their textbook and discusses the answer with them on the board. She demonstrates the calculation on the board, with and without using the protector and compasses, because some students do not have the instruments.

Then she goes from one student to another to check and assist them with their work. Next, she assigns them more exercises from the textbook, and shows more calculations on the board.

Finally Normah gives them homework and ends the lesson.

Lesson 2 – Linear Equations

Normah begins with mentioning the topic “Linear Equation” while at the same time writing it on the board. She writes one exercise for linear equations on the board and discusses with the students how to find the value of “x” (unknown). She demonstrates the calculation to find the value of “x” in the exercise.

She gives another exercise on the board which she asks the students to find the solution by working individually, and then shows them how to find the answer on the board later. She repeats with another question before asking a student to show the calculation of another exercise on the board.

Normah concludes the lesson with some homework for the students to be done at home.
Malay was used exclusively in both lessons, with English for technical terms only. Normah used English in her writing on the board and when articulating the technical terms for the first time, but used Malay for other purposes such as giving explanation or interacting with the students. All notes and exercises in the textbook were written in English, and she used English when reading aloud from the book. But yet, when discussing the topic with the students, she switched to Malay. Her interaction with the students was in Malay, whether with the whole class or individually. However, she used a few English terms such as “centre of rotation” and “protector”, and personal pronoun, “you”, when communicating with the Chinese and Indians.

Excerpt 18 shows Normah used fully Malay in her teaching except for technical terms “rotation” and “reflection”. To ensure the students understood the terms, she asked them the Malay version of the term, and continued her explanation in Malay.

In both of her lessons, she used the whiteboard mainly to show the calculations of many exercises that she wrote on the board. She also used protector and compass in guiding the students to find an object or an image, based on the questions given.
The Students’ Language

Normah’s class comprised of Malay, Chinese and Indian students who used mostly Malay in their conversation with their teacher and amongst themselves. In some instances, Chinese student conversed in Mandarin with their Chinese classmates.

Summary of Language Used in Normah’s Class

This teacher relied on Malay to teach Mathematics which resulted from both hers and most of her students’ lack of proficiency in English. English was only used for technical terms.

5.3 Summary

The analysis in this chapter indicates both commonalities and differences in the language used by teachers and students. These similar and different aspects bring forward a number of themes to be discussed in-depth in subsequent chapters. They are:

The negotiation of English and Malay

The detail descriptions of language used in each lessons in this chapter indicates how both languages were used in majority of the lessons to support learning. There was a variety of ways of switching those languages which include mixing, paraphrasing and translating. Interestingly, the choice of language used depends on a number of factors including the teacher’s level of English. Further analyses that need to be done pertain to two substantial questions:

- Which language was used and for what purpose?
- How the language was used?

Another key aspect of these was the many instances of multimodality in the teaching, which includes the usage of many different kinds of artefacts, board work and video, together with the complexity of verbal and non-verbal gestural languages used in every lesson to achieve “meaningful” learning.
A third aspect is the link between pedagogy and language use, particularly the IRE/F as a dominant student-teacher interaction pattern that can be seen in excerpts provided in this chapter, and the language choices that are involved in this compared to more extended conceptual discussion.

As a means to gain a better insight of the language used and its impact to the teaching and learning of mathematics and science in bilingual settings all of the aspects discussed above will be further unpacked in the following chapters.
CHAPTER 6

Patterns of Classroom Interactions and Language Choice

With the previous chapter, I have described the data set including relevant extracts from videos and interviews as supporting evidence underpinning the analysis. Additionally, the chapter has shown that a number of languages were used in all mathematics and science lessons, except in one mathematics class. In this chapter, attention is given to the languages used in relation to the types of interactions occurring in the classroom. The first section describes the coding scheme applied in this analysis. Then it follows with a description of six lessons which were selected to represent variation in the language use.

6.1 Description of Coding

Overall, there are 15 lessons recorded from both schools, School R and School U. They comprise of eight mathematics and seven science lessons involving two video cameras in every lesson, one capturing the teacher and the other one recording a selected group of students. In this chapter however, six lessons were selected, in order to display the variation of language use by both teacher and students in the classroom. For the purpose of looking at the different subjects, two mathematics and two science lessons were chosen. Beyond that, language used is the fundamental basis of choosing the lessons, with priority given to lessons that have more than one language used. In addition, two other lessons with a single language used were selected to allow a comparison of the teaching when one language is used exclusively.

Coding in this study has been done through Transana, a qualitative analysis software package for video and audio data. This particular software is chosen for its ability not only to manage large video collections, but also its capability to organize video clips into meaningful categories (Afitska, 2009). It becomes one of the most useful features that are applied in this research, facilitating the intention of looking for broader patterns that transcend individual patterns and decisions at the level of the sentence.
In connection with the research question, it is useful to re-iterate here the first two subsidiary questions that link to the way language and interaction is being analysed in this chapter:

**SQ1:** What pattern of language use occurs in mathematics and science classes taught in a second or third language?

**SQ2:** What is the relationship between the different pattern of language use and types of interactions in mathematics and science classes taught in a second or third language?

SQ1 is about the pattern of language use, while SQ2 looks further at the connection between pattern of language use and types of interaction occurring in those classes. Concurrently, the classroom setting is also considered as one of the factors that might influence the choice of language. With the purpose of understanding the reason for choosing a particular language at a time, it is interesting to find out if there are certain broad circumstances under which teachers use English, or Malay or other. For instance, does a teacher use a different language when formally presenting ideas, compared to when that teacher is responding to students questions or when providing illustrations? Does the language change in moving from whole class to less formal, small group work? Are there broad structural triggers during lessons that indicate a switch of language use?

Concerning the questions that arise, the coding scheme developed must be able to trace the relationship between the language used, type of interaction, and type of classroom setting. Consequently, the coding scheme is divided into four broad categories, which are Classroom Organisation, Language Use, Types of Interaction, and Types of Talk.

### 6.2 Classroom Organisation

This category shows the teacher’s organisation of the class activity from the beginning to the end of the lesson. Based on the data, class activity could be organised in three ways, which are whole class work, individual work, and group work.
Whole class work is a form of organisation in which a whole class is taught together or works on similar tasks or activities together. All students were involved at a time, usually to listen to the teacher’s talk. This pattern was usually chosen by the teacher at the beginning of the lesson where a teacher needs to introduce a topic and gives explanation of certain aspects of the topic. Later at the end of a lesson, this pattern occurred again when a teacher wrapped up the lesson with some revision or conclusion. However, some teachers taught in “whole class work” for the whole lesson without having any specific activities for the students. A whole class type is very dominant in all classes selected and appeared in every lesson recorded in this study.

Individual work is a form of class organisation in which each student works on a task individually. The students were either solving exercises given by the teacher, or copying notes from the board.

On the other hand, group work is a form of class organisation in which each individual student works in a group on tasks or activities which are similar. Normally, a group is comprised of four to six students, working together to perform some activities or exercises given by the teacher. Afterwards, the teacher discusses those exercises with the whole class. For science lessons carried out in a science lab, students were already seated in small groups and they did their experiments together with their group members.

6.3 Language Use

English was the designated language of instruction for both mathematics and science at all school levels at the time when the data was collected. However, in the classroom, other languages were also used by both the teachers and students. Malay, Mandarin, Tamil and a mixture of languages were captured in the data collected. Malay as the national language of the country was used frequently in every lesson, except in one mathematics class in which the teacher used English exclusively.

The process of coding the language used in the classroom was one of the most challenging procedures carried out in this study, involving the identification of quite

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11 A further discussion on Malaysia’s language of instruction policy can be found in Chapter 1.
fast shifts in language across substantial portions of lessons. Four types of languages were coded, which are English, Malay, a mixture, and other languages. In the teacher’s sequence graph, only the teacher’s language is coded. Students’ language is only coded in students’ sequence graph involving those parts of the lessons with group work organisation. Below are the protocol used for coding the language:

- If a speaker used one language in a sentence, the sentence is coded as a specific language, be it English, Malay or other languages.
- If a speaker mixed more than one languages in a sentence, that sentence is coded as a mixture.
- The length of a spoken language to be coded as one sentence is at least 10 seconds. Sentences or utterances that are less than 10 seconds either became part of previous or subsequence code, or not coded at all.

The decisions were developed partly practically, and as a response to the need for clarity in deciding how to characterise what was happening. Next are some excerpts taken from the data to exhibit the process of coding the language.

**Excerpt 19**

1. T: Okay we start, okay, we start our lesson. Okay, yesterday you just learnt about the solid geometry, betul? [right?] Anybody can tell me, the name of the solids we just learnt?

2. Ss: Pyramid

3. T: Pyramid,

4. Ss: Cone...cube

5. T: Cone, cube

6. Ss: Cylinder, cone, cylinder, cylinder, cone, cylinder

7. T: Cylinder, cuboids

8. Ss: Sphere

9. T: Sphere. Okay good. So, today we continue same with the solid geometry but today we learn surface area.

10. T: Next time **kalau lewat masuk belakang** [if you are late use the back entrance] (talking to a group of students who arrived late).
Okay, so, surface area, okay, no need to copy. Surface area is the total area of all the faces of the solid, or we also can say that the area of net of the solid. That means, surface area *ni ialah jumlah permukaan* [is the total faces] area *bagi satu* [for a] solid. Boleh faham? [Understand?]

Excerpt 19 is extracted from Bo Yang mathematics lesson of Surface Area. This talk occurred at the beginning of the lesson when she was revising the previous lesson with the students. Turn 1 to 8 are coded as *English*. Although there is one Malay word used in Turn 1, the sentence is not considered as *Mixture* since it involves only one Malay word which is to check the students’ understanding. However, in Turn 10 - 11, the sentences were coded *Mixture* as they contained a mixture of English and Malay phrases.

**Excerpt 20**

1. ST Sir, draw one?
2. T Yalah [Yes], draw one shape, *satu bentuk saja, nak buat apa banyak bentuk?* [only one shape, why do you need more?]
3. T Make a small hole at the edge of what ... edge of shape. *Di tepi...apa...kad tu, you guna pin buat lubang kecil* [at the edge of the card, you use pin to make a small hole].
4. Ss: How many holes?
5. T Three only, three ... three small holes
6. Ss *Kertas cikgu?* [Paper sir?]
7. T *Kertas?* [Paper?]
8. Ss: Ha [Yes]
9. T *Kertas buat apa?* [Why do you need paper?] Ha, *satu bentuk sudah cukup. Buat satu sahaja.* [Ha, only one shape is enough. Make only one.]

Excerpt 20 above is taken from Beng Hong’s second lesson about Stability. Turn 1 is a question from an Indian student who asked in English. Then the teacher replied in Turn 2 by using a mixture of English and Malay. This sentence is coded as *Mixture.*
Next in Turn 3, the teacher continued his explanation with two sentences, first sentence in English while the second sentence in Malay. The first sentence then is coded as *English*, while the second sentence is coded as *Malay*.

6.4 Types of Talk

In describing the talk occurring in the classrooms, teacher talk and student talk were coded separately; they were in fact captured by two different cameras. In the teacher’s sequence graph, only teacher’s language is coded, while students’ language is coded only in the students’ sequence graph. However, in every excerpt chosen, both teachers’ and students’ utterances are shown together as it captured the whole transaction at a time. Teacher talk is described in more detail than the students’ talk as more teacher talk occurred in every lesson compared to the students’ talk.

There are four categories of teacher talk; Curriculum-related Talk, Organizational Talk, Disciplinary Talk, and Informal Talk. On the other hand, students’ talk which was captured in small group activities from every lesson has only two categories, On Task Talk and Off Task Talk.

Curriculum-related Talk is teacher talk about the actual contents or skills to be taught. Included in this description is teacher talk to review content covered in the previous lesson, introduce a new topic, explain, summarize or recapitulate the content of the lesson. On the other hand, Organizational Talk is teacher talk to organize activities and participation patterns; to frame activities; to provide general instructions; to set up; to move bodies; to manage time and space; to tell students what is coming next; to manage transitions and to assist students with their work.

Disciplining, behaviour management, class and student control by the teacher are categorized as Disciplinary Talk, while Informal Talk is a teacher’s informal conversation with the students.

Students’ talk is divided into two subcategories, On Task Talk and Off Task Talk. On Task Talk is the students’ talk related to the topic of the day while Off Task Talk is their of topic or informal talk amongst themselves. As mentioned earlier, students’ talk was only coded during their group work session. During group work activity, students had more space and time to interact with their teacher and friends. Especially
in small groups, there was more freedom for them to talk about either on task or off task matters. Distinguishing between on task and off task might show if there is any difference of language choice when the talk is about the topic or out of the topic. Since all written material, as well as most of the teacher’s content related talk were in English, it is interesting to examine students’ choice of language for on task discussion.

6.5 Types of Interaction

This category is specifically intended to code teacher-student interactions in the classroom. It is divided into three subcategories, Expository, Teacher Led Interaction and Student Led Interaction. Expository is a type of talk where only the teacher talks while students listen quietly. Usually, in this type of interaction, a teacher introduces a new concept or explains some aspects that need to be clarified. Students on the other hand listen to the explanation and wait until the teacher finishes her/his explanation and invites them to ask questions.

In this research, teacher-student interactions in all lessons are dominated by Teacher Led Interaction. It includes all questions asked by the teacher to the students, mainly related to the content. Largely, this category contains the typical IRE/F pattern of interaction. Lessons with this particular discourse pattern are referred to as “Traditional Lessons” by Cazden (2001). In a typical IRE/F pattern, the teacher initiates the exchange, generally by asking a closed, “known answer” question.

Student/s’ questions to their teacher are coded under Student Led Interaction. This category exists largely during group work session when the students need guidance or clarification for the task given to them. More student-centred, investigative or open debate was possible, but in fact did not ever occur in any of the lessons involved in this study.
<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>SUBCATEGORY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASSROOM ORGANISATION</td>
<td>1. Whole class work</td>
<td>A form of organisation in which a whole class is taught together or works on similar tasks or activities together.</td>
</tr>
<tr>
<td></td>
<td>2. Individual work</td>
<td>A form of class organisation in which each individual student works on similar tasks individually.</td>
</tr>
<tr>
<td></td>
<td>3. Group work</td>
<td>A form of class organisation in which individual students work in a group on tasks or activities which are similar.</td>
</tr>
<tr>
<td>INTERACTION</td>
<td>1. Expository</td>
<td>A type of interaction where only the teacher talks while students listen quietly.</td>
</tr>
<tr>
<td></td>
<td>2. Teacher Led</td>
<td>A type of interaction where the teacher asking students questions related to the topic discussed. Contained largely IRE pattern.</td>
</tr>
<tr>
<td></td>
<td>3. Student Led</td>
<td>Student/s asking the teacher questions related to the topic discussed. More student centred, investigative or open debate was possible, but in fact did not occur in all lessons involved in this study.</td>
</tr>
<tr>
<td>LANGUAGE</td>
<td>English</td>
<td>The teacher used English to interact with the students.</td>
</tr>
<tr>
<td></td>
<td>Malay</td>
<td>The teacher used Malay to interact with the students.</td>
</tr>
<tr>
<td></td>
<td>Mixture</td>
<td>The teacher used a mixture of languages to interact with the students.</td>
</tr>
<tr>
<td>Others</td>
<td>The teacher used language other than English and Malay (such as Mandarin) to interact with the students.</td>
<td></td>
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<td>--------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>1. Content Related</td>
<td>Teacher talk about the actual contents or skills to be taught such as reviewing content covered in previous lesson, introducing a new topic, explaining a topic, summarizing a topic.</td>
<td></td>
</tr>
<tr>
<td>2. Organizational</td>
<td>Talk to organize activities and participation patterns, to frame activities, provide general instructions, to set up, to move bodies; to manage time, space, to tell students what is coming next, to manage transitions, etc.</td>
<td></td>
</tr>
<tr>
<td>3. Disciplinary</td>
<td>Disciplining, behaviour management, class and student control by teacher.</td>
<td></td>
</tr>
<tr>
<td>4. Informal</td>
<td>Informal talk with students.</td>
<td></td>
</tr>
</tbody>
</table>
6.6 Presentation of Selected Lessons

Sections ahead will be discussed based on a diagram called ‘Series Keyword Sequence Map’ of each lesson. The ‘Series Keyword Sequence Map’ were automatically generated by Transana during the coding process. The description of the diagram is showed below.

Figure 6.1 displays a time sequence of the classroom organisation, types of interaction, language use and types of talk in Kalsom’s science class at School R. “Force” was the topic discussed in the lesson. A number of materials were used in this lesson such as a whiteboard, CD-ROM, and wooden blocks to help the teacher explain the nature of types of force.

Kalsom’s Lesson

Figure 6.1 displays a time sequence of the classroom organisation, types of interaction, language use and types of talk in Kalsom’s science class at School R. “Force” was the topic discussed in the lesson. A number of materials were used in this lesson such as a whiteboard, CD-ROM, and wooden blocks to help the teacher explain the nature of types of force.
Figure 6.1 Kalsom’s Keyword Sequence Map
Only one group activity was held for approximately five minutes\textsuperscript{12}, while others were whole class events with mainly teacher led interaction. Individual work was organised at the end of the lesson.

Malay was used at the beginning of the lesson when the teacher arranged the students’ seating in their groups. The formal talk started a few minutes later with a long segment of mainly content related talk together with two instances of organisational talk. The language used at the start of this segment was English. The teacher then began to use Malay in her effort to translate her English explanation, and from that point, Malay and English were used through the rest of the lesson. As described in the previous chapter, Kalsom translated nearly all of her English sentences to Malay. This can be seen in Figure 6.1 above, with many instances of frequent and quick shifts between English and Malay throughout the lesson. A mixture was used several times with no real pattern, mostly at the time when the teacher inserted English or Malay terms in her Malay or English sentences.

Expository and teacher led interaction seems to be the dominant type of interaction in this class, with content related talk as the prevailing type of talk. If we look closer at the teacher led interaction line, the teacher had a lot of interactions with the students from start to finish. However, most of the interactions with the students occurred within the first 35 minutes of the lesson. For example, during the minutes 29 to 34, a long segment of teacher led interaction was found. In that segment, the teacher performed some demonstrations in front of the class to identify magnetic substances. She showed a number of artefacts such as test tube holder, clipper and wooden block, and asked one student to perform the demonstration in front of the class. They had some interaction during that segment where the teacher asked and the students answered. Still both languages were used. Many times the students gave their response using the language that the teacher used in her questions. If the teacher asked in English, they answered in English, but if the question was in Malay, the students responded in Malay. However, there were several times when the students answered with a different language from that used by the teacher in her question. These incidents will be discussed further in the following chapter. Both English and Malay

\textsuperscript{12} Although the group activity was shown for only one minute in the graph, the actual length of the group activity (based on researcher’s field notes) was around 5 minutes. This difference occurred because of the poor quality of the video which plays for only one minute of that particular episode.
were used both during the content related talk and organisational talk, while more Malay was used for informal talk.

Generally, English and Malay were used all through the lesson. The teacher began with English, and then started to use Malay as a translated form of her English. This practice went on all through the lesson. Malay was used particularly in group work, and when the teacher gave examples or relating ideas to the students’ daily experiences. There was no clear shift across the lesson from one language to another, and no clear link of language used to classroom organisation (most was whole class) or to type of talk or type of interaction, however there was a period at the end of the lesson, with a teacher led interaction, where English usage was very strong.
Figure 6.2 Zila’s Keyword Sequence Map
Figure 6.2 shows time sequenced coding for Zila’s lesson, in regard to the class organisation, types of interaction, language use, and types of talk. It was a mathematics lesson in a good class at School R. The students were introduced to a new topic, “Statistic”, and were given notes and exercises to be copied from the board. The classroom organisation was comprised of whole class and individual work, with no group work activity. The teacher used the whiteboard mainly to write her notes and exercises, and asked the students to copy them into their exercise books after explaining some ideas about the topic. The many gaps in the language coding that can be seen in the figure above were the time taken by the teacher to write notes, and exercises on the board while the students copied them into their books.

Zila used almost the same amount of Malay, and a mixture of Malay and English in her teaching. English as a single language in an individual sentence was not used at all in this lesson where it appeared only as a mixture with Malay in some parts of her utterances. Mainly English words were picked from the written version of the lesson, which was from the board or the text book. More mixture was used during the content related talk, while Malay was used largely towards the end of the lesson mostly for organisational and informal talk. Most interaction was expository and teacher led. Student led interaction occurred a few times, either when discussing the task given or informal talk with the teacher.

Overall, Zila used Malay and a mixture of Malay and English. Particularly, she spoke more Malay toward end of the lesson for organisational talk. Content related talk however, was almost always a mixture, while informal talk was entirely in Malay.
6.3 Bo’s Keyword Sequence Map
Figure 6.3 displays the classroom organisation, types of interaction, language use, and types of talk in Bo’s lesson. This was a mathematics lesson about “Surface Area”, in a medium class at School R. A number of solids were chosen where the teacher showed the students methods of surface area calculation. The classroom organisation was divided into whole class discussion and group work. Only one group work activity was undertaken in this lesson, in which the students were asked to find the surface area of one solid. The group work activity started from minute 30:00, and was approximately 15 minutes long. During the whole class activity, the teacher guided the students through a surface area calculation for different types of solids. She used the whiteboard as a main medium to guide the students through the step by step procedure for finding a surface area.

Generally, all languages under the language use category were used in Bo’s teaching. English, Malay, and a mixture were the languages used frequently at different times of the lesson, while Mandarin (other languages) only occurred once. Bo began her teaching in English, to introduce the topic “Surface Area” and explained some main ideas and terms that are used in the topic. During the first ten minutes, content related talk was all done in English. Later, she started to use Malay when she had more interaction with the students while showing them the calculation on the board. The earlier use of Malay was to translate the English version of her teaching. She continued with English for the first ten minutes of the lesson, and then started to switch to Malay and moving back and forth from English to Malay until approximately the 22 minute stage of the lesson. During that time too, a mixture was used several times, before the language changed to more mixture from minute 22:00 to 30:00. Afterwards, she used almost all Malay when giving instruction for the group work activity and interacting with the students during the group work. Some student led interaction appeared during the group work section which also happened entirely in Malay.

The next 20 minutes of the lesson was a discussion session of the students’ group work. More Malay was used in this section when the teacher discussed each group’s work on the board. The language then changed to English for a few minutes before she finally ended the lesson with Malay. Some disciplinary and informal talk occurred in this lesson, mainly in a mixture and Malay.
On the whole, the language used in this lesson seems to have a pattern. English was used at the beginning for a formal transaction, before switching to Malay and a mixture during content related talk. The language then changed to almost Malay entirely during group work, followed by more mixture in the discussion section towards the end of the lesson. Finally, English was used again for organisational talk before the teacher concluded the lesson with a small block of Malay.
Beng's Lesson

Series: USM1012

Figure 6.4 Beng's Keyword Sequence Map
Figure 6.4 displays the classroom organisation, types of interaction, language use, and types of talk in Beng’s lesson. This was a medium science class at School U, and the topic was “Stability”. The classroom organisation includes whole class and group work activity. The first half of the lesson was a whole class activity, while the second half was group work activity. Again, at the end of the lesson, there was a small block of whole class teaching when Beng concluded the lesson.

Overall, Beng used English, Malay and Mandarin in his teaching. English was almost exclusively used from the beginning to halfway through the lesson, mostly for content related talk. He used English consistently in explaining the key ideas of the topic, and to have some IRE conversation with the students. It is also important to indicate here that Beng referred to his textbook which is in English most of the time while giving explanations.

Next, he initiated some organisational talk for the students to carry out their experiments, all in English. From this point forward, he started to change his language from English to Malay. More Malay was used towards the end of the lesson, with switching to English in some instances. There were two incidents of the teacher using Mandarin in his class, at the time when he interacted with the Chinese students who kept on asking him questions in Mandarin. Disciplinary talk and informal talk were all in English. Finally, he concluded his lesson with content related talk which was in English.

In general, Beng interacted in English for formal talk, through to the halfway point of the lesson and for content related talk. More switching to Malay occurred when he had more conversation with the students, which was less formal, unscripted talk especially during the group work activity. English were still used in some instances during the group work, particularly when he made an announcement to the whole class while students were working in their groups, as well as when interacting with Indian students.
Figure 6.5 Seow’s Keyword Sequence Map
Figure 6.5 displays the classroom organisation, types of interaction, language use, and types of talk in Seow’s mathematics lesson. In this lesson, Seow taught “Solid Geometry”. The students were arranged to be seated in their groups throughout the lesson. The classroom organisation however involved whole class, individual and group work. Students were given different types of solid geometry objects to identify the solids’ characteristics, and then they were asked to find the net of each of the solids. The teacher had prepared many group activities with a lot of exercises; some to be done in groups while some others to be completed individually. Pertaining to the language aspect, Seow is the only teacher who used English exclusively in her teaching. Both her explanation and interactions with the students were in English. Students talk amongst themselves however used other languages too, namely Malay and Mandarin.

It is shown in Figure 6.5 that organisational talk is the most prominent type of talk in this lesson, followed by content related talk. The teacher had a lot of organisational talk, aligned with teacher led interaction as the dominant way of interaction, in her attempt to explain and instruct the students about the activities and exercises that they needed to complete. The other two types of talk, disciplinary and informal talk, were not found in this lesson.

This lesson is specifically selected for its distinctive character of the language use, which is entirely in English. It is interesting to investigate the background of the class, including the teacher’s and the students’ factors that allowed the teacher to fully implement the language of instruction policy at that time. Worth mentioning here too, is the fact that both the teacher’s and the students’ English are at a good level.
Normah’s Lesson

Figure 6.6 Normah’s Keyword Sequence Map
Figure 6.6 shows Normah’s mathematics lesson for classroom organisation, types of interaction, language use and types of talk. The topic was “Linear Equations”, and the class is a medium class. Normah showed a few examples of linear equations on the board while discussing them with the students. Almost the whole lesson was whole class discussion, except for approximately 20 minutes in the middle of the lesson when the students did problems and the teacher walked round to check their work. Normah used Malay in her teaching. Only a few English terms were used at the beginning of the lesson, and some simple mathematics terms such as “times”, “equal” that she used when guiding non-Malay students in solving the given exercises.

The teacher’s talk was mainly content related where she guided the students by showing some examples of linear equations on the board to the whole class. A number of organisational talk blocks appeared starting from the middle of the lesson, which reflect Normah’s interaction with different students when she went to check the students’ work at their seats. Some students had behaviour issues that created an unpleasant situation in the classroom and led the teacher to instigate some disciplinary talk in order to control them.

If Seow’s lesson (Figure 6.5) was chosen because of its English usage throughout the lesson, this lesson was selected for its Malay usage for almost the entire lesson. Even though there were two small blocks of a mixture seen in the graph, all other teacher utterances were in Malay. Although all exercises discussed were written in English, Malay was the dominant choice for the teacher to interact with the students. Again here, factors such as the teacher’s and students’ backdrop will be unpacked later.

6.7 Students’ Keyword Sequence Map

In this section, two students’ keyword sequence maps were selected to show the types of interaction and language use during group work activity. Analyses shown in all figures above captured only the teacher’s language, as well as some discussions of the students’ language in the teacher-students interaction. As mentioned earlier, students had significant space and time to talk only in their group work activity. The selection of these two graphs of students talk is aimed at examining the students’ language while interacting with their teacher and friends. It is also interesting to find out which
language was used in their discussion, and whether the discussion was related or not to the topic of the day.
Students' group from Beng's lesson (Stability)

Series: USMHFSU

Stability
- Classroom Organisation: 1. Whole class work
- Classroom Organisation: 2. Individual work
- Classroom Organisation: 3. Group work
- Interaction: 1. Off task
- Interaction: 2. On task
- Language: English
- Language: Malay
- Language: Mixture
- Language: Others

Figure 6.7 Beng's Students Keyword Sequence Map
Figure 6.7 displays the keyword sequence map of a selected group of students from Beng Hong’s class. This group was comprised of Malay and Chinese female students. Only their talk during group work is coded in this graph to show which language they were using and what topic was being discussed. At the time when the teacher talked in the whole class mode, students mainly sat quietly and listened, and only spoke when they were asked to respond by the teacher. The group work was held for approximately 20 minutes, during which time they did an experiment to find the centre of equilibrium of an irregular shape. From the figure above, it can be seen that two languages were used frequently in their talk, Malay and Mandarin. It is likely that the Malays talked amongst them in Malay, while the Chinese talked in Mandarin. Most of the interactions were on task discussion, with students talking amongst themselves to complete their experiment.

From the teacher’s graph of the same lesson (Figure 6.4), English was used almost exclusively in the first half of the lesson. Thus, most of the ideas were introduced in English, as well as all notes being written in English. However, the interesting point here is that in the students’ graph, English was not used in the students’ group work. They preferred to interact with each other by using their native language, Malay and Mandarin, even when discussing content that had been introduced in English.
<table>
<thead>
<tr>
<th>Series: RMMBY5F2 Coding with teacher video 100912</th>
<th>Series Keyword Sequence Map</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom Organisation: 1. Whole class work</td>
<td></td>
</tr>
<tr>
<td>Classroom Organisation: 2. Individual work</td>
<td></td>
</tr>
<tr>
<td>Classroom Organisation: 3. Group Work</td>
<td></td>
</tr>
<tr>
<td>Interaction: 1. On task</td>
<td></td>
</tr>
<tr>
<td>Interaction: 2. Off task</td>
<td></td>
</tr>
<tr>
<td>Language: English</td>
<td></td>
</tr>
<tr>
<td>Language: Malay</td>
<td></td>
</tr>
<tr>
<td>Language: Mixture</td>
<td></td>
</tr>
<tr>
<td>Language: Others</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.8 Bo’s Students Keyword Sequence Map
Figure 6.8 shows the keyword sequence map of a group of students from Bo Yang’s mathematics class. The group consists of five Malay students, a mixture of male and female. They were given a piece of paper with a picture of a solid. The task was to find the surface area of the solid. Malay was used almost exclusively in their talk. Only a few English words were spoken, particularly for mathematics terms such as “times”, “square” and “bracket”. At the beginning of the group work session, more off task talk was captured, while plenty of on task discussion was found in the middle of the session. This seems to match the teacher’s dominant language during the group work, which was Malay, rather than English which was dominant when establishing the conceptual ideas.

6.8 The Ways Teachers Use Language

With the exception of the mathematics teacher from School U, Seow, all other teachers used English and Malay, and some used Mandarin too, alternately or as a mixture to deliver their lesson. Although Zila (School R) and Normah (School U) used almost all Malay, they still imported technical terms from English to be introduced to the students, with more English words being used in Zila’s lesson.

A number of broad language use patterns emerged from the cases discussed above:

1. Almost all teachers used formal English to begin their lesson, in particular in conjunction with resources in English. Except in Seow’s and Normah’s cases, Malay increased gradually during the class (Kalsom, Bo, Beng), while in Zila’s, the language shifted from a mixture to Malay.

2. In some cases such as Bo’s and Zila’s, the mixed language was often a transition between the use of English, and Malay, or an initial step leading into the use of Malay (Zila’s case).

3. Generally, the structure of the lessons was typical. It started with whole class, moved to group work or individual work, but sometimes reverted to whole class. This seems to influence the language pattern, which mainly began with formal English, then moved to mixture or Malay, and finally went back to formal English (Kalsom’s, Beng’s, Bo’s).
4. In most cases, English was only strongly used in content related talk. This can be seen clearly in Kalsom’s, Beng’s, and Bo’s classes. Organisational talk however was almost always in Malay and was often associated with group work (Kalsom’s, Beng’s, Bo’s).

5. English was never used for either disciplinary or informal talk. Both types of talk occurred mainly in Malay.

6.9 The Ways Students Use Language

According to Barnes (1976), there is evidence of universal patterns in teaching behaviours across subject areas and even across countries. For instance, the “two thirds” rule where two-thirds of every lesson consists of speaking and the teacher performs two-thirds of that speaking, as suggested by Flanders (1970). This scenario seems to be the reality in most of the classes involved in this research. Students only talk when they were asked to, or when they had the opportunities to talk and discuss with the teacher and their friends during group work.

Interesting features of students’ language:

1. Students’ talk occurred mainly during group work. Other than that, it consisted of one or two words response to the teacher’s questions during whole class activity, especially during teacher led interaction.

2. Students’ both on task and off task talk during group work was almost always in their mother tongue. English was never used as a complete sentence, but rather used for several technical terms borrowed from the teacher’s content related talk.

3. During whole class activities, students in their response to questions used the language that the teacher used to ask them, except in several cases. These cases mostly involved whole class answering, while individual answers usually used the same language as the teacher’s.
6.10 Discussion

In this chapter, six lessons have been selected to highlight the relationship between language choice and interaction patterns. Generally, interaction patterns have a significant coincidence to the choice of language. As the language of instruction, the usage of English was restricted mostly to content related talk only, mainly during whole class sessions. Malay and a mixture of languages were used in most other types of talk, and types of interaction.

Key points in those highlighted episodes will be discussed in depth in the following chapter, guided by the questions below:

- Why is English strongly related to content related talk while Malay to others?
- What drives the gradual switch to Malay during a lesson?
- What is the function of the mixed language?
- What influences students to use their native language?
CHAPTER 7

Influences on Teachers’ and Students’ Choice of Language

This chapter addresses the third research question SQ3: *What are the situational influences on teachers’ and students’ choice of languages in mathematics and science classes taught in a second or third language?* In the first section, three lessons are selected to discuss the underlying reasons for language patterns in those lessons. Then, the discussion moves to the language used in the classroom. In this section, language is divided into three broad categories as a way of looking at patterns of language used. The next section examines the influences of the teachers’ and students’ language preferences on language choice. The final section then looks at the way students were supported to learn mathematics and science in English, from the perspective of the literature.

7.1 Underlying reasons for patterns in each lesson

In this section, three lessons were selected to investigate the language patterns in the classrooms. The lessons were chosen from Kalsom’s, Bo Yang’s and Beng Hong’s classes. The selections of the three lessons were based on the amount of language used in all lessons, by both the teachers and students. All selected lessons displayed the usage of English and Malay dominantly, with some amount of a mixture of English and Malay, and another language which was Mandarin. It is important to have lessons with all types of languages used in order to show how and when the language shifted, in conjunction to the types of interaction and activity occurred at that time.
Language used in Kalsom’s lesson has no clear shift across the lesson from one language to another, and no clear link of language used to classroom organisation (most was whole class) or to type of talk or type of interaction. However, there was a period at the end of the lesson, with teacher led interaction where English usage was very strong. Apart from that, there were several segments in which Malay was largely used, along with teacher led and content related talk. Thus, three sequences involving strong usage of English or Malay were selected from this lesson to unpack how, when and why the language was used. Sequence 1 captured the scene of language shift from all English to more Malay. This is the first segment in this lesson in which the teacher used a lot of Malay. The main purpose of choosing this sequence is to find out the reason for suddenly changing to more Malay, after a while of interacting in almost all English.
Sequence 1 (From minute 0:07:11 – 0:11:26)

Overall, there are 54 Turns in this sequence. However, only selected Turns are shown in the analysis, while others are described in the discussion sections. The sequence begins at 07:11 minutes, where Kalsom has just introduced the effect of force. She explained earlier about the meaning of force, which is “a push or a pull”, and the fact that force cannot be seen, only felt. She started with pressing and squeezing a piece of plasticine in front of the class, to show that force can change the shape of an object. There were some conversations between the teacher and the students, most likely IRE/F (Initiation-Response-Evaluation/Feedback) pattern, which was all in English until Turn 13, in which the teacher began to use Malay.

Transcript of Sequence 1:

<table>
<thead>
<tr>
<th>Turn 1</th>
<th>T</th>
<th>I can change the shape of an object. OK what am I doing now? (13 Pressing and squeezing a plasticine in her hand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turn 2</td>
<td>Ss</td>
<td>...</td>
</tr>
<tr>
<td>Turn 3</td>
<td>T</td>
<td>What is the...</td>
</tr>
<tr>
<td>Turn 4</td>
<td>Ss</td>
<td>shape...</td>
</tr>
</tbody>
</table>

13Word or sentence in brackets (…), and is **bold** and *italic* is an additional information of the context.
Turn 5  T  Shape of the plasticine? *(Showing the students a round shaped plasticine)*

Turn 6  Ss  Sphere...

Turn 7  T  Sphere...Round...OK what happen now when I give a push? I flat the... *(Pushing and flattening the plasticine on the front table)*

Turn 8  Ss  Cylinder...

Turn 9  T  OK we can change from sphere to cylinder OK? OK... What else? OK, what happen when I give more force? *(Mashing the plasticine on the table)*

Turn 10  Ss  Rectangle...

Turn 11  T  Rectangle? The shape become...

Turn 12  Ss  Rectangle...

Turn 13  T  Flat ¹⁴ya ... ah tadi ada bentuklah sikit... ada isi, ni bila kita bagi dia daya yang lebih, kita tekan dia, dia jadi nipis. [¹⁵it has some shapes before, but when we gave more force, we pushed it, it becomes thin] Ha that’s the effect of force yes, ha panjang jadi bulat, [from long to round] round, ha saya bagi force saya tekan lagi, jadi bulat [huh I gave force I pushed harder, it becomes round] *(Squeezing the plasticine)*... yes so that’s the effect of...

Turn 14  T & Ss  Force

Turn 1 to 14 above show the teacher’s language changed from all English, to alternately Malay – English. Malay was used at the first time by the teacher in Turn 13, as a response to the students’ “incorrect answer” to her question (Turn 9 to 13). Students responded “rectangle” twice, while the teacher was expecting them to say “flat”, as she did in Turn 13.

¹⁴ Word or sentence in bold is word or sentence that is spoken in Malay.
¹⁵ Word or sentence in square bracket [...] and is italic, is the English translated version of the Malay word or sentence.
“Flat” ya...ah tadi ada bentuklah sikit... ada isi, ni bila kita bagi dia daya yang lebih, kita tekan, dia jadi nipis. [it has some shapes before, but when we give more force, we push it, it becomes thin]

“Flat” and “rectangle” are two different forms of an object which the object can have at one time. Probably the plasticine was in the shape of a “flat rectangle”, which makes both answers acceptable in that case. The teacher however, was referring to the appearance of the plasticine while the students were looking at its geometric forms. Based on the elaboration given by the teacher in Turn 13, she might assume that the students needed more explanation about how force can change the shape of the plasticine. Following that, she explained that particular process in Malay, while at the same time demonstrating it in front of the class. Interestingly, Malay was chosen here. Probably because the elaborated nature of the explanation she judged needed the language resources of Malay, either for the students or for herself, or both.

Explanation often requires someone to use complex sentences, as well as incorporating complex ideas which is always most comfortably done in one’s own language. According to Tang (2002), teachers often use L1 (first language) in beginning and intermediate classes to give instructions, explain meanings of words, explain complex ideas and explain complex grammar points. L1 serves a supporting and facilitating role in the classroom.

Another interpretation could be made from this example is that switching between two languages may be serving as a resource for elaborating ideas while expanding, repeating or adding information. In this context, Kalsom’s change of language from English to Malay has facilitated her in elaborating the shape “flat” that she was expecting from the students, by repeating the explanation and demonstration she had done earlier (Turn 1 to 9). Her use of everyday Malay, accompanied by some demonstration, could be seen as mediating her explanation with a rich resource that might help increase her students’ understanding.

Kalsom maintained her IRE style in the rest of the conversation. From Turn 15 to 27, she moved to discuss another effect of force, which is “change position of an object”. When referring to the notes on the board, Kalsom used English. She then translated the English sentence, “Force can change the position of an object” by having some transaction with the students to complete her Malay sentence in chorus. The students
seem to follow the language used by Kalsom as their responses were also in Malay. Next in Turn 19, Kalsom switched to English again when demonstrating the concept. Kalsom pushed and pulled a wooden block on the front table to visualize the concept discussed. English was used fully in Turn 19 to 24, involving words such as “push”, “pull”, “wooden block”, “forward” and “backward”. However, in Turn 25, when elaborating the idea, she switched back to Malay.

**Turn 25**

T K...the wooden block backward...**bergerak** position dia [the position moved]...**ok itu kalau depan belakang ya** [ok, that is the case for forward backward]...**kalau kiri kanan pun boleh** [it also can move to the left or right]...uh...going to...left (**Pushing the wooden block to the left**)...going to...

(Pushing the wooden block to the right)

Kalsom expanded the notion of “pushing forward and backward” to a different direction such as left and right. Again Malay was used in this case, to facilitate the elaborating of ideas beyond the discussion in the notes and textbook.

Another interesting example in this sequence can be found in Turn 28 (below), in which Kalsom linked the concept discussed above, with the students’ daily experience. By using a wooden block, she demonstrated a child playing a toy car, and how the child can freely change the direction of the toy car. The act of changing the direction of the toy car could help the students visualize the concept more clearly, as the example given is related to their everyday life. They might have experienced it themselves, or have siblings doing the same action while playing with a toy car at home.

**Turn 28**

T **Macam adik awak main kereta mainan kan** [like when your brother playing with his toy car] ... **kereta control ke, kereta lumba ke** [control car or racing car] ... **ong ... ong ... eh ... so ... awak nampak dia gunakan daya ya** [so...you can see he uses force]...your brother give the force...and change the direction...**ikut sukalah dia** [it is up to him] ... **ong ... ong ... nak pergi ke mana** [where he wants the car to go] (The teacher used the wooden block as a toy car and demonstrated with her hand how force can change the position of the toy car) ... **ong ... ong ... berlanggar dia kata kan** [accident...he said] **eh ... kat rumahlah** [at
...adik-adik kita kan [our brothers] ... ha nampak ya [ha you can see right] ... can change the position of an object ... sama jugak dengan bola ping pong ni [it is the same with the ping pong ball] (Showing a ping pong ball) ... this ping pong ball ... bila dia berjalan [when it moves] ... moving right?

Turn 29  S  Yes

The first sentence in Turn 28 above serves as a clue to the students that the discussion is going to be somehow informal, by changing the language to Malay. The everyday Malay is used here in conjunction with thinking about everyday contexts. The word “macam” (like) in this context is usually used in an informal situation, while the synonym of “macam”, which is “seperti” (such as), is always used in a formal context. Similarly, the particle “-kan”, and “ke” [-kah] in Malay indicates the informality of the language as well as the context. Bringing both the language and the context to an informal mode perhaps could ease both the teacher’s effort and the students’ understanding. The formal words such as “give the force” and “change the direction” might be found in the textbook are in English. It is almost as if she was surrounding the English text book script with Malay interpretations and anecdotes.

In Turn 46 to 53, Kalsom once again used an anecdote, serving as a bridging analogy to assist the students in applying their understanding to a different context.
In the actual transcript above (Turn 46 to 53), Kalsom used a soccer game as an example of how force can change the speed of an object. In Turn 46, she requested her students to give the name of several soccer players they knew. A few names were given, but she chose Drogba and Zinedin as an example. Kalsom began to switch her language to Malay in Turn 47, and continued using almost Malay exclusively up to the end of the sequence (Turn 53). Next in Turn 52, she sketched a picture of the two soccer players, with Zinedin passing a ball to Drogba. The act of stopping the ball with Drogba’s foot was the main point that linked to their discussion earlier. The teacher tried to bring her students’ imagination to a common scenario that they might have experienced before and arguably made it easier for them to relate with the concept discussed. Only in Turn 52 English was used twice, that is “...playing football” and “...pass the ball”. As in Sequence 2 above, she used English for a simple and formal concept, while switching the language to Malay as a way on bringing the local context into the students’ world.

As mentioned earlier, Sequence 1 was selected to display the reason behind the shifting from English to Malay. In contrast with the previous sequence that shows strong usage of Malay, there were points in this lesson where Kalsom used mainly English. Sequence 2 and 3 below are samples of how English was used strongly in her conversation with the students.
Sequence 2 (From minutes 0:16:32.9 to 0:19:25.4)

Sequence 2 is taken approximately from minute 16:32 until 19:25, at the time when Kalsom started to show the whole class a CD-ROM related to the topic Force. She selected the part of interactive activities which required the students to watch the animation and then to choose a correct answer to match the related animation.

Displayed on the screen were four animations of different activities that were; two people pulling each other, two people pushing each other, a boy playing cricket, and a girl playing with a sponge. Each animation can be clicked on, and the screen then will display the selected animation with choices of answers to choose. If the correct answer is clicked, the voice will say “that’s correct”. Since the CD-ROM was having

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This CD-ROM is an interactive CD-ROM which functions to assist a teacher in the teaching and learning processes in school. It comes together with the textbook, both supplied by the government. Amongst the content of the CD-ROM are:

- Answers to all exercises in the textbooks.
- Suggested additional and advanced activities or alternative activities such as remedial and enrichments.
- A question bank which can gather and generate questions for use in tests and assessments.
- Multimedia teaching materials, especially for teachers to use in the classroom, such as additional interactive activities, tutorials and power point presentation.
- Internet access so teachers can gather additional information on a related topic in the textbooks (CD-ROM MyCD, 2011)
a sound problem, the teacher decided to explain the content of the CD-ROM while it was playing. Then in Turn 2, she started to repeat the voice in the CD-ROM, and paused a while to wait for the students to respond. Up to Turn 7, almost all exchanges were in English. The Malay phrases used were directly translated to English, as in Turn 1, “saya nak” and Turn 2, “Nampak eh?”

Transcript of Sequence 2:

Turn 1  T  Before that, saya nak [I want to]...I want to show the ... uh ... CD ...what we have learnt before. OK the sound cannot function ... OK ... I can explainlah what happen. *(the CD is playing and the sound can be heard but not loud)*

Turn 2  T  Nampak eh? [Can you see?] Can you see? OK some daily life situation. OK. Some people perform some action ... yes. *(Repeating the sound of the video). OK. (The CD is showing an animation of two people pulling each other). OK what is your answer...*

Turn 3  Ss  Pull...Pull

Turn 4  T  ... about what the two person was doing?

Turn 5  S  Pull...

Turn 6  T  Is it pull?

Turn 7  Ss  Yes

However, in Turn 8, Kalsom used Malay to confirm and elaborate the students’ answer. She elaborated the meaning of “pull” in Malay, as a way of linking the word with the action showed in the animation. Then she stressed the answer (pull) again in English.

Turn 8  T  OK pull...*sorang tarik ke sana, surang tarik ke sana yeh* [one person pull to one side, one person pull to another side]...OK pull. OK let us check the answer... *(the teacher then listens to the CD saying "that is correct"). OK that is correct...pull. OK next question...
In Turn 9 to 17, English was fully used again. These Turns comprised of teacher-students conversation based on the exercises from the CD-ROM. As before, Kalsom repeated the CD-ROM’s voice and waited for the students to choose the correct answer for each activity shown on the screen. Besides repeating the CD-ROM’s voice, she was also confirming the students’ answer (as in Turn 10, 14, and 16). However, when elaborating the students’ answer in Turn 18, she switched to Malay.

Turn 18  

T  Given the push, so, change the shape. *(CD says "that's correct")* OK. Dia tekan ya, so sponge tu jadi leper. [She pushed yes, so the sponge became flat]. Tapi sponge tu boleh kembali ke bentuk asallah. [But the sponge can become to its original shape]. OK, walaupun dia leper, adakah jisim dia rubah? [OK, even though it is flat, is the mass changed?]

Turn 19  

Ss  Tak. [No].

Turn 20  

T  OK, the mass is same yes, tak berubah. [unchanged].

Again in this extract the usage of Malay was unscripted and occurred at the time when the teacher needed to expand and confirm the students’ answer. It would appear that the switching of the language happened automatically to assist the teacher with her elaboration of the concept learnt – “change the shape” and “change the mass”.

This sequence is chosen to show how English can be used quite exclusively with the assistance of materials such as CD-ROM. Next is an example chosen where English is used while discussing an exercise sheet in a whole class activity.
Sequence 3 (52:54 to 57:19)

Sequence 3, which contains 44 Turns wholly, is the final sequence selected from Kalsom’s lesson. It is the last part of the lesson in which the teacher discussed an exercise sheet with the whole class by asking selected students to give the answer for each question. She distributed the exercise sheet to every student at approximately minute 49:00 and briefed them before assigning them to complete the exercise individually. She explained beforehand that the students were required to give the answer for all questions which has been divided into three sections, in order to give definitions of force, to identify the effort used, and to identify the types of force used. The students were given nearly three minutes to complete the task. Sequence 3 begins when the teacher discussed the answers with the students.

In Turn 1, Kalsom began the discussion by choosing one student, Natasya, to provide the answer for the first question. She used English fully. There was silence from Natasya (Turn 2), that influenced the teacher to give some clues (Turn 3) to the answer required, and she did this in Malay. The clues given included recalling the first note she had given earlier which can also be found in the textbook. This information was delivered in Malay, probably to make it easier for the student to remember the related information. Finally, when no answer was given by Natasya (Turn 4), Kalsom
gave the answer in English before translating it in Malay, as can be seen in Turn 5. The students’ response in Turn 6 was also in Malay as they were completing the teacher’s sentence which was in Malay. Turn 7 is an informal instruction whereby Kalsom emphasized the accepted answers that should be provided by the students. She gave the instruction in Malay, as it is informal, but then changed her language to English when once again she stressed the meaning of “force”.

Transcript of Sequence 3:

Turn 1  T  OK class let us discuss number one, explain the meaning of a force. I would like ... uh... Natasya, please give your answer? Loudly please. Number one, what is the meaning of force?

Turn 2  Natasya  ...

Turn 3  T  The first thing that we have learnt. Nota saya nombor satu tadi. [My first note just now]. Dalam buku teks pun ada, [It is also in the text book], what is the meaning of force.

Turn 4  Natasya  ...

Turn 5  T  Double "p"... push and pull that... act on the object yeah. Daya tarikan ataupun tolakan yang bertindak ke atas... [A push or pull that effect on an...]

Turn 6  T&Ss  Objek [Object]

Turn 7  T  Ha bila awak ada jawapan pull and push tu, ha saya dah terima ya. [When you include pull and push in the answer, I will accept it]. Force is a pull and push that effect on the object yeah. OK yang lain dapat? [OK, did everybody get it?]

Turn 8  Ss  Dapat [Yes]

Turn 9  T  Betul jawapan awak, sama dengan Natasya? [Is your answer correct, same as Natasya’s?] OK number two "A", who like to answer? Volunteer, number two "A". OK Firdaus, number two "A", what is the effort?

When checking the students’ answer, she switched back to Malay and received response in Malay from the students (Turn 7). From Turn 9 to Turn 44, almost
English exclusively was used in which the teacher had a lot of exchanges with the students while discussing the answer for each question in the exercise. The exceptions were in Turn 15 and Turn 27 when again she switched to Malay whenever she translated and/or elaborated the answer given by the students. For instance, in Turn 15, Kalsom translated the student’s answer “change the shape” before elaborating the process of how the shape was changed.

```
Turn 15   T   Change the shape. Ia akan merubah bentuk. [It will change the shape]. Daripada bulat dia dah terbelah dua, betul?
[From round it has split up into two, right?]
```

The question they were discussing was about dividing round shape plasticine into two pieces. While in Turn 27, Malay was used to explain the accepted answers in the context of the question, in which both “direction” and “position” were changed.

```
Turn 21   T   OK so the effect?
Turn 22   Hazwan  Change the direction
Turn 23   T   Change the direction and?
Turn 24   Hazwan  ...
Turn 25   T   Direction and?
Turn 26   Ss  Position
Turn 27   T   Position. Boleh dua ya, dalam satu situasi boleh dua jawapan. [It can be two, it can be two in one situation]. Masa awak tarik tu direction dan kedudukan dia dah berubah. [When you pull, both the direction and position changed]. OK "C"... uh, OK please stand up. (Asking a student to answer the question).
```

Other than that, all transactions occurred in English. In most of the exchanges, the teacher read the question on the exercise sheet, while the selected students gave a one or two words answer, involving simple and basic English.
As mentioned earlier, these two sequences (Sequence 2 and 3) were purposely selected to explain the usage of strong English in some parts of the lesson. This is shown in Figure 6.1 (Kalsom’s Keyword Sequence Map) where a number of big blocks of English appeared in the lesson. Since the teacher used both English and Malay fairly balanced in this lesson, it is interesting to unpack the reason behind the strong usage of English in these contexts. Looking at the full transcript of both Sequence 2 and 3, there were materials used in assisting the teacher in these cases. CD-ROM and exercise sheets were used in those sequences, and could be seen as supplying the language to the teacher. The English used by Kalsom was mostly imported from the CD-ROM and exercise sheet, which enabled her to continuously converse in English.

Unlike other times during the lesson, although the teacher was guided with notes written on the board and in the text book, her focus was not solely on the notes. At the same time, she was conducting multiple activities, such as making several demonstrations in front of the class, drawing pictures on the board, as well as facilitating the students during their group work session. Her language changed from English to Malay back and forth. But, when she dealt with the CD-ROM and exercise sheet, she managed to maintain her English throughout the session.

Generally, three sequences were selected from Kalsom’s science lesson based on the strong usage of English or Malay. As English was the language of instruction, using as much English as possible in the classroom was seen as complying with the current requirement. In this lesson, this was achieved through consistent use of English language teaching materials such as CD-ROM and exercise sheet. However, in many other segments in the lesson that particularly involved complexity of ideas, Malay was the chosen language.

17 The data has been collected in 2010 in which English was the language of instruction for mathematics and science in Malaysia. The Government of Malaysia then has decided to revert the language of instruction to Malay in 2012. However, the cohort of students involved in this data is given opportunities to continue learning mathematics and science in English towards the end of their secondary schooling.
Bo’s Lesson

Teacher: Bo Yang (Ethnic Chinese)
School: R (Rural)
Class Level: Medium
Lesson: Mathematics
Topic: Surface Area

Overall, all languages were used in Bo Yang’s lesson. She began her lesson with English fully, before moved to more Malay and a mixture until the end of the lesson. Mandarin was spoken once in her conversation with a Chinese student, somewhere before the lesson ended. Sequence 1 is captured approximately 10 minutes after it is started, for the length of about three minutes.

Sequence 1 (0:10:03.6 to 0:13:21.9)

Figure 7.4 Bo’s Lesson Sequence 1

This is the starting point for Bo Yang to switch to more Malay, and the first time for her to use a mixture in her teaching. The first ten minutes of the lesson was nearly all in English. During the first ten minutes, Bo Yang introduced the topic, Surface Area,
in which she recalled the students’ past knowledge about solids. Also, she supported the students with the formal definition of “surface area”, which can be found in their text book. Another activity was guiding the students to calculate the surface area of a prism.

Turn 1 in this sequence begins with a question from the teacher about the name of a solid that she displayed on the board, which was a prism. She asked in English, and heard no response from the students (Turn 2). She translated the question to Malay and only then received an answer from the students as in Turn 4. She acknowledged the answer “prism” in Turn 5 in Malay before continue instructing them to calculate the surface area in English. The full transcripts are shown below.

| Turn 1 | T | OK this solid we also call what? |
| Turn 2 | Ss | ... |
| Turn 3 | T | Solid ini kita panggil apa juga? [What do we call this solid?] |
| Turn 4 | Ss | Prism |
| Turn 5 | T | **Prism juga eh** [Prism also]. Prism. OK. So, this one is first one, this one is second one eh. OK firstly what we need to do? |

At this stage, the switching to Malay is seen as translating English utterances to support and increase students’ comprehension. The response given in Turn 4 indicates that somehow the students should be given an alternative language in order for them to understand the question. Furthermore, this class is rated as a medium class which generally means that the students’ academic achievement is at a medium level, as well as their competency in English. Using Malay serves as a mechanism to cope with the language issue.

While continuing her calculation on the board, Bo Yang went on with her calculation of the surface area. Then in Turn 7, she asked a question in English, and received an answer in Malay from the students (Turn 8). The students replied “**Lukis net**” when answering the teacher’s question about the step they should be doing before labelling the area of the surface.
Next, another incident of Malay usage can be found in Turn 11 when again Malay was used for the purpose of translating a technical terms (isosceles triangle). Although the students should be learning mathematics since primary school in English, other languages particularly Malay were always used when there was a need to do so. Establishing the students’ knowledge such as introducing the technical terms in the national language is seen as a common practise in both mathematics and science classes. Since they have been learning mathematics bilingually, it is essential for them to be informed of the technical terms in Malay. At the same time, the Malay terms could be serving as a link to the students’ concept understanding that they perceived in their own language.

Turn 6  Ss  Label
Turn 7  T  Label. Before label?
Turn 8  Ss  **Lukis net** [Draw the net].
Turn 9  T  OK yes, draw the net. OK this one is the base ah. So...rectangle...this way is six, nine, OK continue from this way?
Turn 10  Ss  Triangle.
Turn 11  T  OK triangle. Isosceles triangle. **Segi tiga sisi sama eh** [Isosceles triangle eh]. **Betul**? [Correct?]
Turn 12  Ss  **Betul**. [Correct]

Later in Turn 13, Bo Yang started to use a mixture of English and Malay.

Turn 13  T  OK continue from this base, **OK kawasan sini**. [OK this area] Faces from this way, **apa shape dia**?[what is its shape?]
Turn 14  Ss  Rectangle.
Turn 15  T  OK rectangle. OK this way **berapa**? [how many?]
Turn 16  Ss  Six.
A mixture is a category of more than one language occurred in one sentence. Two mixed sentences were found in Turn 13. The teacher still used more English in her mixture. In every mixed sentence, only a few words were in Malay. Amongst the words are “kawasan” (area), “apa” (what), and “berapa” (how many). However, she maintained to use English for some of the basic terms in mathematics, such as base, shape, and rectangle.

In the rest of the conversation, more Malay was used instead of a mixture. It seems obvious that Malay occurred particularly when Bo Yang interacted with the students, such as whenever asking them questions. Apart from “berapa” (how many) and “apa” (what) that found in Turn 13 above, “tak tau” (don’t know) and “betul?” (correct?) are some other words or phrases that were asked in Malay. For example in Turn 19 below, she articulated “tak tau” in Malay, while the rest of the utterance which contains mostly instruction, was in English.

<table>
<thead>
<tr>
<th>Turn</th>
<th>Actor</th>
<th>Dialogue</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>T</td>
<td>Six?</td>
</tr>
<tr>
<td>18</td>
<td>Ss</td>
<td>Tak tau [Don’t know]</td>
</tr>
<tr>
<td>19</td>
<td>T</td>
<td>OK tak tau [OK don’t know], OK good. And this way OK continue also same, a rectangle. This way is nine, this way?</td>
</tr>
<tr>
<td>20</td>
<td>Ss</td>
<td>Tak tau [Don’t know]</td>
</tr>
<tr>
<td>21</td>
<td>T</td>
<td>OK tak tau [OK don’t know], and this way is?</td>
</tr>
<tr>
<td>22</td>
<td>Ss</td>
<td>Four. OK. Betul permukaan dia? [Is the surface correct?]</td>
</tr>
<tr>
<td>23</td>
<td>Ss</td>
<td>Betul. [Correct.]</td>
</tr>
<tr>
<td>24</td>
<td>T</td>
<td>Satu, dua, tiga, empat, lima. [One, two, three, four, five] One, two, three, four, five. Betul eh? [Correct eh?]</td>
</tr>
<tr>
<td>25</td>
<td>Ss</td>
<td>Betul. [Correct.]</td>
</tr>
</tbody>
</table>

In the next set of conversation (Turn 26 to 39), Malay is found in most of the Turns. For instance in Turn 28, in the first Malay sentence (cikgu buat dekat sini eh), the teacher informed the students about the location of her next drawing. This utterance occurred when the board was nearly full of the teacher’s previous drawing that she
needed space to draw another one. The next sentence which was also in Malay (So ini empat, ini berapa?), was a question to the students about the calculation of the solid. Once again, Malay was used in a question type. Meanwhile, all other sentences in Turn 28 which are instruction, were in English. The same situation can be seen in Turn 30 and 36, in which Malay was used to ask questions to the students.

Turn 26  T  So now label A, B, C, D and E. OK, so same, area A. Can we find the area A?

Turn 27  Ss  No...

Turn 28  T  Cannot ah. OK. We need to solve for this triangle first. OK. So...cki gu buat dekat sini eh. [I will do it here] OK. Draw the triangle first. So ini empat, ini berapa? [this is four, this one is how many?]

Turn 29  Ss  Enam... [Six...]

Turn 30  T  OK when you divide two, become three...three. OK. This is right angle triangle, so boleh tak you cari B? [can you find B?]

Turn 31  Ss  Boleh. [Can.]

Turn 32  T:  OK apa B? [OK what is B?]

Turn 33  Ss  B Square

Turn 34  T  OK same. B square equal four square plus three square.

Turn 35  T & Ss So... sixteen plus nine. Twenty five. So B is five.

Turn 36  T  OK ini dah dapat, boleh you cari sini? [OK you have found this one, can you find here?]

Turn 37  C  Boleh. [Can.]

Turn 38  T  So this way is what?

Turn 39  Ss  Five.

The discussion above illustrates how Malay was always used by the teacher to ask questions related to the calculation on the board. This could be seen as a strategy to scaffold the students’ involvement in the discussion. By shifting the language to
Malay, the students’ awareness of the discussion could be increased through them comprehending the question better. In other words, even though some of the students could be lost in her English instruction during the calculating session, the “shifting to Malay” strategy might help the weak students to at least respond to her question. Malay was used in other situations as well, such as to translate English utterances and technical terms.

**Beng’s Lesson**

**Sequence (0:34:04.7) to (0:38:41.9)**

![Diagram showing classroom organisation and language use]

The language used in Beng Hong’s lesson can be divided into three sections: English exclusively, English and Malay, and English only. The classroom activity seems to determine the types of language used as the language shifted fairly consistently with the transition of the classroom organisation. In general, he used almost English exclusively during the first half of the lesson, in which they had a whole class activity. Later, the students were given a task to be completed in small groups whereby the teacher’s language switched to more Malay. Sequence 1 above is approximately five minutes long, begins at minutes 34 of the lesson. A small group work session was carried on for about four minutes, during which the teacher was having a lot of organisational talk with the students while he walked from one group to another.
The sequence begins with an Indian student asking the teacher regarding the number of drawings they need to have in their group, when the teacher first came to his group. The conversation occurred in English up to Turn 5 as the teacher had some difficulties understanding the question. The student had to repeat “Draw one” three times, and then only the teacher replied in Turn 6 by using Malay. The teacher’s response was a confirmation of the number of shapes needed, and asking back the student of how many did he think he needed to draw? Afterwards, the teacher changed the topic to an informal talk when he asked the same group whether Patrick (a name of one student in the class) was absent on that day. Until Turn 10, the conversation topic was about the name of absent students on that day, and the conversation went on in Malay.

<table>
<thead>
<tr>
<th>Turn</th>
<th>Role</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S</td>
<td>Sir, only draw one...</td>
</tr>
<tr>
<td>2</td>
<td>T</td>
<td>Hmm?</td>
</tr>
<tr>
<td>3</td>
<td>S</td>
<td>Draw one?</td>
</tr>
<tr>
<td>4</td>
<td>T</td>
<td>Round one?</td>
</tr>
<tr>
<td>5</td>
<td>S</td>
<td>Draw one?</td>
</tr>
<tr>
<td>6</td>
<td>T</td>
<td>Ya lah [Yes], one shape. Satu bentuk saja [Only one shape]. You nak berapa banyak bentuk [How many shape do you want?]... Itu Patrick tak datang? [That Patrick is absent?]</td>
</tr>
<tr>
<td>7</td>
<td>S</td>
<td>Tak, tak [No, no]. Patrick Ng, Mumtaz, Mumtazali..</td>
</tr>
<tr>
<td>8</td>
<td>S2</td>
<td>Ha, Mumtaz dengan Mumtazali dua orang ha? [Huh, is Mumtaz and Mumtazali two different person?]</td>
</tr>
<tr>
<td>9</td>
<td>T</td>
<td>Atiqah</td>
</tr>
<tr>
<td>10</td>
<td>S</td>
<td>Ha, dia tak datang tu bukan perkara yang... [Absent is not..]</td>
</tr>
</tbody>
</table>

Next in Turn 11 below, the teacher clarified an instruction to the whole class, approximately half minute from his previous conversation. At this time, he was approaching another group of students while observing their work. The instruction in Turn 11 was given as a result of his observation to the students' progress when some of them were still unsure with the procedure of the experiment. In Turn 11, the Malay utterance was roughly a translated version of his English utterance earlier. This case
of using Malay is seen as paraphrasing through translating. He included a clarification statement in his Malay version, which is “...you guna pin eh” (you use pin) to detail the process of making holes on the card. Then he continued in English when mentioning the number of holes to be made.

Turn 11  T  Make...make a small hole ah at ...ah at the edge of what...edge of shape. Di tepi apa kad tu, eh you guna pin eh, buat lubang kecil [At the edge of the card, you use pin, make small hole]. Three only, three. Three small holes.

Next, from Turn 12 to 15 below, he went to another group and responded to the group’s question. One of the group’s members was asking something but the question was unclear (Turn 12). Then the teacher asked for clarification since he couldn’t hear the question clearly. He used Malay to ask (Turn 13), indicating that the student’s question was in Malay too. The student then repeated his question by asking for more papers (kertas) in Turn 14. The teacher’s response in Turn 15 shows that he was unhappy with the situation that some of the students were still blurred with the experiment. Turn 15 includes of questions and clarifications. When the teacher disapproved the student’s request to have more papers, it shows that he was questioning the reason behind it. They were asked to have only one shape for them to accomplish the task. The usage of Malay in Turn 15, “...satu bentuk...” (...one shape...) is seen as emphasizing the substantial aspect in his explanation as it is crucial for the students to understand the procedure clearly.

Turn 12  S  ...
Turn 13  T  Apa? [What?]
Turn 14  S  Kertas sir. [Paper sir]
Turn 15  T  Kertas? [Paper?] Kertas buat apa? [Paper for what?] Satu, satu bentuk eh sudah cukup. [One shape is enough.] Buat satu saja. [Only make one.] Mengapa tiga...satu cukup. [Why three...one is enough].
Next in Turn 16 below, Mandarin was spoken by a Chinese student. Some of the Chinese students were constantly interacting with the teacher in Mandarin, but the teacher always avoids replying in Mandarin. This situation can be seen in Turn 17, 21 and 23. Several times at the end of the group work session that the teacher replied in Mandarin. However in this sequence, none of the teacher’s responses were in Mandarin.

Turn 16  S  Speaking in Mandarin
Turn 17  T  Ha yes yes
Turn 18  S  Lukis ke? [Draw?]
Turn 19  T  Bentuk tulah... [That shape...] irregular shape
Turn 20  S  Speaking in Mandarin
Turn 21  T  Apa ini jangan sentuh tu... inikan...jangan sentuh...jangan apa... ikat dia...tak boleh ikat dia. [Don’t touch this...this one...don’t touch...don’t...tie them...cannot tie them.] Ini lubang nikan...lepas tu di sini...eh tak boleh tu. [This hole...then here...no cannot...]

Turn 22  S  Speaking in Mandarin
Turn 23  T  Haa. Trace eh.
Turn 24  T  Hey cannot... cannot hold the string ah. Itu benang itu tak boleh pegang tau...kasi dia apa... bebas ha. [That thread cannot be touched...let it...free] Free...free

Another instance that shows Malay was used for the purpose of paraphrasing can be seen in Turn 21. The teacher has announced the instruction to avoid touching and tying the string. Yet some of the students were still doing it wrongly so that the teacher instructed them once again in their own language. He repeated the same thing in Turn 24 to another group by using both English and Malay.

Generally, there are three main reasons for shifting the language in this lesson. The teacher used more English during expository talk, but shifted to more Malay when he had more interaction with the students during group work session. Further, he used Malay during informal talk with the students, and finally to translate and paraphrase his English instruction.
7.2 Language in the Classroom

In these classes, the language of instruction was mainly English in the early part of the lesson, supported by resources in English. All three teachers began their lesson with English, and started to use Malay at a certain point of their lesson in different circumstances as discussed in the sections below. However, as the official medium of instruction, English was used back and forth throughout the lessons. At the beginning of each lesson, a typical introductory sequence occurred which comprised of introducing the topic and familiarizing students with technical terms and formal definitions was carried out in English. Each teacher was assisted by a variety of English resources, such as written notes on the board and the English textbook.

As mentioned earlier, using as much English as possible in teaching and learning is important in order to comply with the language policy. In reality, English was used at the beginning and at the end of each lesson, as an introductory and concluding language. In between, all teachers changed their language to Malay, a mixture or Mandarin, or maintained English depending on the appropriateness to the teacher’s and the students’ needs and the context.

Malay, a mixture, and Mandarin, were the other languages used in the selected lessons. As the national and the official language of the country, as well as the Malay ethnic group’s first language, Malay was used the most after English. The many ways and situations in which Malay was used in the classrooms have been discussed in the previous sections. Eleven situated contexts of Malay usage were unpacked in those sections, which can be divided into three broader categories of language.

The different situations of Malay usage (as discussed in the previous sections) can be divided into three broad categories of language, which are translating, establishing meaning, and interacting (Table 7.1). In looking at language as a system of signs, in some circumstances teachers need to translate English words or sentences. In these cases, the aim was to match English and Malay words as closely as possible to enable students to relate the Malay words with their own understanding in their own language. The second category is establishing meaning which involves the activities of elaborating, linking, and introducing a concept and idea. Using Malay in these contexts involves using language as a “lens” for the students to “see” better. In other
words, with comprehensible language including analogy, students could increase their understanding of such concepts and ideas. Finally, the category of interacting involves language as part of social interactions, in which the change of language from English to Malay is seen as a way to improve teacher–student interactions.

There are 11 situations of using Malay across all teachers as shown in Table 7.1. The first three situations are categorised as translating, each involving translating activity. Technical terms, questions and students’ responses were the main components that were translated into Malay. In these situations, language is recognised as a series of codes in which the translation could assist the students to match the English with the Malay words. At this stage, students are required to understand the words that are being translated.

In the next group which involves three situations - elaborating complex ideas, linking students’ daily experience, and bringing in local context, - language is not just a series of codes but involves a broader notion of language. These situations involved the teacher discussing complex ideas and concepts. The movement of language happened not between words anymore, but entailing chunks of ideas around the concepts discussed. For instance, when a teacher talks about an abstract science concept, she or he needs to talk around the concept and bring in the local context in order to make the concept meaningful to the students. The teacher could also link the concept to students’ daily experiences that relate to the situation discussed. When the notion becomes difficult to talk about, as well as difficult for the students to comprehend, the teacher had the need to change the language to Malay in order to access more vocabularies and examples to refer to. Richer explanations and discussions could be more readily carried out in their own language than in their second or third language.
Table 7.1 Malay Usage in the Classroom

<table>
<thead>
<tr>
<th>Broader Categories of Language</th>
<th>Name of the teacher</th>
<th>Kalsom</th>
<th>Bo Yang</th>
<th>Beng Hong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malay was used when</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Translating</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Translating question</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Translating technical terms</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Translating and checking student’s response</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Establishing meaning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elaborating complex ideas</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Linking students’ daily experience</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bringing in local context</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Interacting</strong></td>
<td></td>
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<tr>
<td>Clarifying instruction</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asking question</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interacting with students in small groups</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Having informal talk with students</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Responding to students who used Malay</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The third category looks at language as a way of interacting. Teachers’ and students’ interactions included clarifying instructions, asking questions, interacting with students in small groups, having informal talk with students, and responding to students who used Malay. As part of social interactions, language is used consistent with the way people communicate with each other. When a teacher interacts with students, the teacher needs to modify the language according to the students’ level of understanding. Most of the interactions in this category involved a two-way communication that required the students to be responsive. Changing the language to Malay could improve the students understanding and allow them to take part in the interaction.
Further, interacting with students either in small groups or discussing informal topics is indicative of the intimate setting which allows more freedom in the language used. With a small number in the audience, the teacher had more flexibility to choose the most comfortable language for both the students and themselves. Particularly while engaging in off topic talk, it is unusual for people to use an unfamiliar language. They often prefer to converse in their own language, and this is evidenced from the data which shows almost all informal and off topic talk occurred in Malay.

In relation to this research, Kramsch’s (1998) perspectives on language can be related to these categories of the ways in which teachers used Malay in their lesson. Kransch argues that there are three different ways of using language. As a system of signs, language is used as a series of codes which involving letters, words, sentences, forms and structures. As part of social interactions, language is used based on how people give meaning to language. It entails the ways in which they communicate, express meaning and express language. Since language and culture are two sides of the same coin, another usage of language is to reflect and express cultural reality.

As a first language to the Malays, and a national language to Malaysians, the teachers and students shifted to Malay dominantly to express ideas that are closely related to their world. In other words, they tended to use Malay whenever talking about topics that demanded sophisticated vocabularies.

7.3 Language Competency and Preferences of Teachers

From 1958, the transition from English to Malay as the main medium of instruction in education system in Malaysia began. From 1970 onwards, there was a gradual shift in the medium of instruction in the English medium schools and, by 1982, the Malay language became the sole language of instruction (Puteh, 2006). This was followed by the first year in all courses at the university level taught in Malay in 1983 (Puteh, 2012). Since then, the thousands of students who have graduated from local universities have received their education in the national language, Malay. Most teachers nowadays are the products of this education system with Malay as the language of instruction.
When the decision to revert the language of instruction for mathematics and science was made in 2003, one of the issues that arose was the English language competency of the teachers. Teachers who had been learning and teaching in Malay were expected to perform effectively in English, to teach subject specific knowledge, when at the same time, the teachers themselves have proficiency problems with the new language of instruction. The next few paragraphs will review each teacher’s history of language use.

Kalsom is a young teacher who has only four years of teaching experience, and certainly was schooled both at the primary and secondary level in Malay. However, she was trained to teach Science in English. In her teaching, she was the only teacher who translated nearly all her English to Malay, or contrariwise. It was clear from the data that she commenced and concluded her lessons in English, and her English usage was strong in conjunction with the assistance of teaching resources, such as written notes, text book, and CD-ROM. Apart from that, Malay was used dominantly to demonstrate some experiments in front of the class, or to provide narratives as enrichment for the students. In her interview, she rated herself as “average” in English, admitting that her English competency is at a medium level, particularly in listening.

Next is Bo Yang, an ethnic Chinese teacher with 14 years of experience in teaching. She was educated through three different languages in three different level of studies, Mandarin (primary level), Malay (secondary level), and English and Malay (tertiary level). She believed her English competency was “average”, but she appeared to be competent enough to teach in English. The language used in Bo Yang’s class started with English too, after which her language moved from one to the other in accordance to the types of talk she was engaged in with her students. English was used mainly for content related talk, while Malay and a mixture were generally for organizational and off topic talk.

The next teacher is Beng Hong, who is a male ethnic Chinese, with 20 years of experience in teaching. He felt that his English competency was average, but he managed to use the language competently in his teaching. Beng used English strongly for content related talk, specifically during whole class discussion. Nonetheless, other languages particularly Malay, were used for organizational talk.
Zila is the youngest participant teacher, with teaching experience of less than a year. Like most young teachers nationwide, she was schooled in Malay at all school levels, but was trained to teach Mathematics in English. Although she felt her English was “average”, and at the same time used more mixture of Malay and English in her teaching, her English could be considered as “good”, based on the observations in the classroom and during interviews. The languages that she used in her teaching were mainly Malay, and a mixture of Malay and English. For content related talk, a mixture was dominantly used, while more Malay occurred during organizational talk.

Another senior teacher was Hasnah, with 13 years of teaching experience. Although she was educated in Malay from primary to tertiary, she had attended both the in-service course and the school’s in-house training for teaching science in English. She believed that her English was average, and was confident to use the language in her teaching. In the classroom, Hasnah used English dominantly for content related talk, using Malay mainly for organizational and off-topic talk. The students however, had difficulties in comprehending her teaching, mostly due to their low level of competency in English.

Normah is another novice teacher who has two years of experience. Similar to Zila, Normah was schooled in Malay for every level, but was trained to teach Mathematics in English. She rated her English as “weak to average”, and therefore used Malay exclusively in her teaching. English was used only for specific terms in mathematics, and in written work.

Like Zila and Normah, Anis is considered new in the area of teaching. She has five years of teaching experience, and was schooled in Malay, except for her tertiary education. She rated her English competency as “average”, but conducted both of her lessons mainly in English without difficulty.

The final teacher is Seow Chin, who is the most senior teacher amongst all of the teacher participants, with 30 years of teaching experience. She was very competent in English, as she was schooled in English at every level of her education. At the same time, her students’ competencies of English were also good, which enabled her to carry out both of her lessons in English exclusively, successfully.
In general, all of these teachers possessed at least an average level of English competency that allowed them to understand and use the language reasonably. However, in dealing with a language to teach a specific subject that has its own discourse and terminology requires particular skills and ability. Based on the sequences from most teachers, their English occurred particularly when drawing on formal terms, and on the support resources, where the language demands on them were not high. There was also a lot of translation work that occurred mainly on formal terms, and distinct from informal language. Whenever they needed to go further with explanation and negotiation, for instance to tell stories or linking the concept to the students’ daily experience, they tended to shift to Malay. The language shifting had allowed them to fulfil the language demands, either for themselves or their students. A number of sequences related to this issue could be found in Kalsom’s, Bo Yang’s, and Beng Hong’s lessons. The teachers’ language level seemed to be a major influence on the balance of language use. Where the demands on their competence were greatest, that was where they switched to Malay.

To effectively teach in an unfamiliar language, both teacher and students need a good competency level in that language. Teaching and learning process would become unsuccessful if only one party has a good command of the language. This is indeed another issue concerning those teachers’ choice of language, which is the students’ English competency. All teachers except Seow claimed that students’ level of English was their main concern in shifting the language. Additionally, a number of teachers reported that students preferred to learn in Malay. In the next section we will examine this proposition.

7.4 Language Competency and Preferences of Students

Judgements about the students’ level of English were generally informed by the teacher’s opinion given in the interview, as well as from the ranking of classes in which the students were placed. According to the teachers, a majority of students from the top classes were rated as “average”, while the average classes were rated “average” or “weak” in their English competency. This teacher rating was made based on their involvement with their classes for nearly a year in teaching mathematics or science. All classes were streamed depending on their overall academic achievement,
which also broadly reflects their English competence. By comparison, students from top classes should have better command of English than their peers in the average classes.

Nevertheless, the amount of English used in a lesson was not necessarily related to the ranking of the classes. Amongst four top classes involved, in only one class (Seow’s class) had English been used exclusively without any difficulties. In the other three top classes (Kalsom’s, Zila’s and Anis’) the teacher switched to other languages in order to complete their journey. The language pattern in Seow’s lessons indicates both teacher’s and students’ good level of English is necessary if English is to be used exclusively in teaching and learning. Further than this it would seem that teachers’ language competence was at least as important as students’ in determining language patterns.

In most cases, students tended to respond to a teacher’s question in the language that the teacher used to ask the question. Thus, a question asked in English would always receive a response in English, whether in a top or average classes, which indicated that the students’ language competency was at least up to the level required for basic teaching and learning.

In relation to the students’ preferences of the language of instruction for mathematics and science, some of them expressed disappointment about the shift in policy away from English. Although they admitted to facing some challenges to learn in English, they appreciated the opportunity to use English in learning the two subjects. Even though evidence from their language use patterns shows their first language was predominantly used in their private group talk, this is an issue of choosing a comfortable language particularly for an off-topic discussion, more than a measure of competence as such. On the other hand, some other students who particularly struggled with the language of instruction were looking forward to going back to their first language to learn the two subjects.

Properly scaffolding students’ learning mathematics and science in English places extra demands on the teachers’ English. They need to be strategic in how they themselves use English and Malay in their teaching. However, the scaffolding occurred mainly through translation of specific terms rather than through higher level support. Students were trained to be aware of the translated version of the specific
terms in Malay mainly for the examination purposes. Questions asked usually
involved closed questions, which limited the opportunity for the students to use
extended language. As a way to improve the students’ understanding of the topic, they
should at least be given a space to have their own ideas or thoughts in English. These
scenarios could be taken as an indication of the extent to which the vision of
educating students to learn to use English in mathematics and science is being realised
in these classrooms.

7.5 Scaffolding Students to Learn Mathematics and
Science in English

There has been a lot of research concerning how students are best supported to
develop their English competence on order to effectively learn mathematics and
science. One of the essential elements of the teacher’s duty is to scaffold the use of
English with students increasingly challenged and supported to use complex
language. A number of studies have identified the intellectual resources and learning
needs of English language learners. Kelly and Breton (2001) investigated how two
bilingual elementary school teachers guided their students to engage in science
inquiry through particular ways of framing problems, making observations, and
engaging in spoken and written discourse. The results show that students need to be
engaged in conversations through questioning, paraphrasing ideas, varying use of
languages, making links to other classroom experiences, and devising interactional
contexts for students to “talk science”.

Himmel (2012) suggested a solution for English language learner teachers who are
facing challenges in supporting the academic English development of the students.
Besides having regular content objectives, she recommended teachers should have
language objectives for their lessons. Even though the English learners may not be
fully proficient in the language, implementing language objectives enables the
students to have access to the curriculum content also. Amongst the guidelines for
having appropriate language objectives in a lesson are deciding just what are the key
vocabulary, concept words or academic words that students will need to know.
Another crucial element as a guideline is the language skills necessary for the lessons,
such as reading and reporting specific information. The setting of such language objectives will benefit not only the students but the teachers as well.

In considering the ways in which students might successfully learn a subject through a language that is different from their first language, a diagram (Figure 7.6) suggested by Setati et al. (2002) shows the possible routes that can be chosen in order to support students to reach competence in the formal written language of the subject, in the language of instruction.

![Diagram showing possible journeys from informal talk in the main language to formal talk in a second or third language](image)

**Figure 7.6 Possible journeys from informal talk in the main language to formal talk in a second or third language**

Figure 7.6 suggests several possible ways of using the languages for learning mathematics, science and English in classrooms in South Africa. The first step in one route is to use the informal written or spoken language of the subjects in the main language. The route then moves to either the formal version of the subjects in the main language or to the informal written language of the subjects in the language of instruction. Another possible journey could begin with informal spoken language in
the main language and move straight to the formal spoken language in the language of instruction. Whereas there are many different paths that students can take to suit their ability of learning, all journeys seemed to begin with the main language. The final destination then is to be able to achieve the formal written discourse of the subjects in the language of instruction.

In Malaysia however, the policy and practice indeed encourages the opposite movement. The data show teachers began their lesson in English, generally with the support of resources that were all in English. The language was then either maintained in English or shifted to other languages particularly Malay, or a mixture, before reverting to English again at the end of the lesson. The three diagrams below display the language move in all three lessons.
Figure 7.7 Language Movement in Kalsom’s Lesson
Compared to Setati’s language journey in Figure 7.6, Kalsom’s lesson (see Figure 7.7) displays a journey in the opposite direction. The lesson began with formal written science in the language of instruction (which is the final destination in Setati’s language movement), when the teacher commenced the lesson by referring to the science textbook. Then she introduced the word “force” and the formal definition of “force”. The language then changed to formal spoken science in the main language, whereby Kalsom translated the word “force” in Malay, before elaborated her explanation in the informal spoken science in the main language. At the final stage, the lesson was concluded again in the formal spoken of the language of instruction.

Language movement in Bo’s lesson is shown in Figure 7.8. She used the formal spoken mathematics in the language of instruction at the beginning of her lesson to revise the previous lesson that the students had learnt. Then she wrote the formal definition of “surface area” on the board while saying it aloud. Here, she started to use the formal written mathematics in the language of instruction. Next, she translated the main component of the definition in formal spoken mathematics in the main language. While having informal interactions with students during group work, Bo Yang used the informal spoken of both the main language and the language of instruction, before wrapping up the lesson with a formal spoken mathematics in the language of instruction again.
Figure 7.8 Language Movement in Bo’s Lesson
Figure 7.9 Language Movement in Beng’s Lesson
Figure 7.9 demonstrates the language movements in Beng’s lesson. Beng used almost fully English in his lesson. In the earlier part of his lesson, formal spoken and written science in the language of instruction was used, mainly because he was referring to the textbook. The language moved to the informal spoken science in the main language when he did some translation during his explanation. Then he used both the informal spoken of the main language and the language of instruction when engaging with students during group work. At the final part of the lesson, Beng stressed the important concepts learnt in the lesson, again by using the formal spoken science in the language of instruction.

Interestingly, none of the three lessons use the written form except for formal English. At the same time, all three lessons followed an opposite direction to that of the Setati et al. (2002) language route. Those diagrams (Figure 7.7, 7.8 and 7.9) indicate a totally different process of learning in a second language to that developed by Setati et al. (2002). Instead of building from students’ prior knowledge and experience toward mathematics or science concepts expressed in formal language of instruction, which could be seen as the constructivist recommendation for effective learning, mathematics or science are presented in the formal language from the beginning. The teacher and students then build talk around the formal language that unpacks it in spoken form, in both languages (English and Malay), depending on their (teacher and students) competence. Arguably, this is consistent with the pedagogy that prevails in Malaysia, with teachers presenting the scientific view up front, rather than building from where students are at with their knowledge. Further, this pattern reflects a connection between the formal pedagogy prevailing in Malaysia, the provision of resources in English, and restricted opportunity provided for students to express complex thoughts in English.

To tease these connections out further, teachers in Malaysia are obliged to follow a “busy curriculum” which requires them to complete a number of topics in a specific time, which restricts the possibility to have more discussion or to give their students more space to express their own ideas in their own language. This scenario is also related to the many tests and examinations that the teacher needs to conduct, either monthly, quarter and annually as part of the requirement for formal assessment of the students. The restricted ways of using the language in both mathematics and science
lessons could reflect the impact of the formal pedagogy prevalent in the country. The language competency aims seem to be secondary, as teachers’ focus is to finish the syllabus within the given time. Moreover, teachers in Malaysia were advised to use the language of instruction as much as possible, at the same time avoiding the usage of any other languages. This issue of curriculum pressures and traditions will be discussed further in a following chapter.

The Setati et al. (2002) diagram (Figure 7.6) is considered complete only if we talk about the spoken and the written modes of language in a bilingual setting. However, there is an increasing attention being paid to semiotics in science and mathematics practice, and classrooms. In dealing with languages used in bilingual classrooms, there was a lot more than simply talk and writing going on, for instance 3D artefacts, mathematical symbols and equations, gesture, video and board work diagrams that were part of the learning environment. It is often argued that mathematics in particular is not so dependent on spoken language because of its elaborated sign systems. In order to understand the learning going on in these classrooms, and the semiotic resources that are involved in establishing understandings expressed in English, we need to extend Setati and Adler diagram to include other modes, and examine the role of semiotic resources in these classrooms. That analysis will be the subject of the next chapter.

### 7.6 Summary

In discussing the situational influences on teachers’ and students’ choice of languages, this chapter has focussed on the ways in which both teachers and students selected the best language for them to teach and learn. The analysis also includes their language backgrounds and patterns to show that their language competence and preferences were important influences on language use, with students’ language competence playing a more secondary role. Eleven different contexts for switching to Malay have been identified. In the final section, the language pathways of the three lessons are analysed to compare with the possible language journey in Setati et al. (2002) diagram, and found to be very different. The next chapter will extend the discussion related to the Setati et al. (2002) diagram, in relation to the role of semiotics resources in teaching and learning.
CHAPTER 8
Multimodality in Teaching and Learning Mathematics and Science

In this chapter, the fourth subordinate research question is discussed, which is SQ4: How do different representations and artefacts support teaching and learning mathematics and science classes taught in a second or third language? In the first section, attention is given to the justification of selecting three lessons to be focused in this chapter. The sequences of representations employed in those lessons are then presented in the subsequent section, focusing on the ways the teachers incorporated multiple modes of representations in their teaching, and the way this affected their language negotiations. This is followed by a discussion of the role that multimodality plays in teaching and learning mathematics and science, particularly in bilingual setting.

The focus is given to the multimodal aspects of teaching mathematics and science in the classroom, particularly to the ways in which all elements are orchestrated. In every lesson, sequences involving different kinds of representations are selected to highlight how each aspect contributes to the meaning making process, specifically in assisting the development of natural language. The classroom video recording used in this research allows the analysis of multimodality, since visual, spatial symbolic and embodied modes are all part of the video record.

8.1 Why the Three Lessons

Three lessons were selected for analysis in this chapter, from Kalsom’s, Bo Yang’s and Seow Chin’s lesson sequences. The main basis for choosing those lessons is to provide continuity from the previous chapter. Both Kalsom’s and Bo Yang’s lesson were discussed in depth in relation to the language used in the earlier chapter. Thus, choosing the same lessons can possibly show if there is any relation between the way multiple modes of representations and language are used. In addition, Seow Chin’s mathematics lesson that employed English exclusively is discussed in this chapter, in
order to examine how she used multiple modes of representations in her lesson. The multimodality of teaching approach in this lesson might be one of the contributors for her to teach in English successfully without the need for translation into Malay.

The second reason for selecting lessons in this chapter is related to the ways in which the teachers incorporated multimodality in their teaching. Unlike other teachers, the three teachers have incorporated multiple modes of representations such as natural language, image, writing, material artefacts, 3D objects, video, and gestures in their lessons. The interplay between all elements is a crucial process in the teaching and learning mathematics and science in bilingual settings; natural language alone is not sufficient. This issue becomes the focus of this chapter.

### 8.3 Sequences from Selected Lessons

**Kalsom’s Lesson**

In her science lesson, Kalsom introduces the definition of “force”. The lesson starts with a formal English definition that links the word “force” with the inter language words “push” and “pull”, in English, which is then translated into Malay. Inter language is considered as “a new hybrid language” that developed through the use of everyday language while students work on making sense of the scientific language (Olander & Ingerman, 2011). For instance “push” and “pull”, these are words that operate as bridges between the formal language of science, such as “force”, and the many everyday words that approximate to this concept. In this case it might be English words such as “squeeze, twist, stretch or roll” (Hubber et al., 2010) or their Malay equivalents.

Next, the point is illustrated with gestures of “push” and “pull”. In front of the class, she demonstrated a push and a pull with her hand, the transcript is shown in Excerpt 1, Turn 3.

**Excerpt 1**

```
1 T Force ... OK, page fifty-eight ... OK look a note in front of you (reading the notes on the board) ... OK force is a pull or of
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push of an object ... daya adalah satu push ... apa push? [force is a push ... what is push?]

2 Ss Tari [pull]...Tolak [push]

3 T Tolak [push] (showing a sign for pushing with her hand) ... or and pull (showing a sign for pulling with her hand) ... pull apa? [what is pull?]

4 C Tari [pull]

(RSGKKTFl)

In Turn 3 above, she uses her hand to show a sign of a “push” and “pull”. On the one hand, the purpose is to establish a visual sign for push and pull. On the other hand, its purpose is to establish an embodied understanding of the nature of push and pull with the body. She begins to use Malay in Turn 3, when her students are unsure of how to respond to her question about the translation of “push” in Malay. They reply “tarik ... tolok” (see Turn 2), before Kalsom says “tolak” in Turn 3, at the same time demonstrating a push with her hand. This is followed by saying “and pull” while demonstrating a pull with her hand. Using a gesture while translating the word “push” in Turn 3 is important here as a way of mediating the teacher to link the word “push” to its equivalent in Malay. The gesture itself provides a visual language of the word, which help the students to connect all three elements -“push”, “tolak” and “the act of pushing” together. Figure 8.1 below illustrates the synergism of the three elements discussed.
Next, she demonstrates force by pushing and pulling a wooden block on the front table. This action is seen as a way of linking force direction and effect on motion. At the same time, it also displays the embodied sense of what force is and what forces do. While demonstrating, Kalsom used both English and Malay in explaining her action. For instance in Turn 1 and 5 in Excerpt 2 below, she pushes and pulls a wooden block while saying the word “push” and “pull”. Again here she tried to represent the movement of the body while giving force to an object, and link the action to the word “pull” and “push”, to establish the students’ understanding of such concept.

Excerpt 2

1  T  OK when I push (pushing the wooden block)...what happen?
2  Ss  Forward
3  T  The wooden block...
4  Ss  Forward
5  T  Forward. When I pull (pulling the wooden block)...what happen?
As seen in Excerpt 2, Kalsom and her students use English from Turn 1 to 6 in their conversation. Then she begins to use Malay in Turn 7, which is when she expands her explanation about the possible movement of the wooden block, while at the same time demonstrating the movement of the wooden block with her hand. She uses “depan belakang” (front and back) while pushing and pulling the wooden block forward and backward, and “kiri kanan” (left and right) when pushing the wooden block to the left and right side. At least, two translation incidents can be discussed from this sequence. The first one is to expand the notion of “changing the position of the wooden block” by changing the language. Malay was used to explain the situation, which indicates that extended explanation is arguably easier in the first language. The second incident is to relate the concept of “force that can change the position of an object”, with the action of doing it.

The linking between the act of pulling and pushing, which provides the visual language, the embodied mode, which links with the body or gesture, and the usage of both English and Malay, is seen as a crucial step of doing this particularly in a bilingual setting. Language alone seems unable to provide a basic understanding of the concept, even though both languages are used. Changing language in Turn 7 can be seen as a strategy of providing more details to the concept discussed, but by combining all items including gesture, artefact and talk, has enabled Kalsom to show the possible ways of comprehending the concept.

In the middle of the lesson, Kalsom showed the students a CD-ROM supplied by the government about the topic “force”. From the images contained in the CD-ROM, she establishes a visual language of a series of activities, which were two people in a tug
of war, some people shifting furniture, a boy playing cricket, and a girl playing with a sponge – all were moving image representations which further linked visual language with embodied understandings. Using arrows to symbolize the direction of the force is an important step in explaining force. In the video, arrows were introduced in the sequence “direction of force”. Arrows were used to replace the picture of a person pushing a dresser (see Figure 8.2). Even though the importance of arrows has not been discussed explicitly by the teacher, the visual shown in the video serves the purpose of establishing a symbolic, abstracted language of force. By looking at the direction of the arrow, students should perceive the idea of where and how force is applied to an object. Meantime, the act of the teacher “pointing to the arrow” while saying “force” (see Figure 8.2) has the effect of marking the significance of the arrow.

The arrows then become more crucial when the teacher discusses frictional force, where the force and friction have a different direction (see Figure 8.3). Arrows provide an indirect, abstract way of identifying when and where a force is acting as well as the direction of the force, since forces cannot be observed directly.
Figure 8.3 Arrows showing a different direction of force and friction

This segment thus shows how multiple modes are used and linked in establishing the meaning of force in Kalsom’s lesson. The movement between languages, and between modes, is shown in Figure 8.5, which is again an extension of the Setati et al. (2002) diagram. Each movement from one type of language (such as “formal spoken in the language of instruction” or “informal written in the main language”) to another is called a “route”. Based on the analyses of the lesson as described above, there were four routes taken in this lesson, which involved only formal spoken and written...
science language in the language of instruction, and formal spoken and informal spoken science language in the language of instruction. These are shown in Figure 8.5.

In this figure (see Figure 8.5), the way that gestures, artefacts and images operate to support the language transitions are made apparent. For instance, in Route 1, which is the movement from formal written science in the language of instruction to formal spoken science in the language of instruction, gesture and artefact were the multi-modes accompanying the natural language. Using hand to demonstrate a visual sign for push and pull, as well as using plasticine and a wooden block, become a complete package to define “force” in this context. Another example can be seen in Route 2, which is from formal spoken science in the language of instruction to the formal spoken science in the main language, when more modes came into play. Image, video, gesture and arrow mediated the teacher to further explain “force” in this segment. Apart from the natural language emphasised by Setati et al. (2002) and other writers as the core feature of meaning making, multiple modes that appear in every route can be seen as central features of the teaching and learning process.
Figure 8.5 Multimodality in Kalsom’s Lesson
Bo’s Lesson

This lesson is about “surface area”, where Bo demonstrated a lot of calculation on the board. At the beginning of the lesson, she revises the previous lesson by asking the students the name of the solids that they have learnt. Then she writes “surface area” on the board, as well as the formal definition of surface area, while at the same time saying aloud the written words. To this point, everything is conveyed in English except when she translates the main idea of surface area in Malay. Simultaneously, gesture is used to point to word by word that is written on the board by using the index finger.

Later, she introduces a picture of a prism and begins to show the calculation of the prism to the students, in whole class work. She repeats the same activity for another three prisms and one pyramid, all in whole class work which involves the students doing the calculation together with her. Three essential elements identified in these sequences of calculations are the pictures of the solids and their nets, the written and spoken language, and the gestures. As discussed earlier, the written language was all in English in all lessons. As well as using English in her written form, her spoken form was also mainly English.

Figure 8.6 Bo using gesture to show the lengths of the lines
Figure 8.6 is one example of showing Bo using her finger to show that the length of “d” in Picture 1 is equal to the length of “d” in Picture 2. She points at “d” in both pictures while explaining the equality of both lines. By pointing to the specific area while talking can help the students to focus on the areas discussed. At the same time, the gestural mode was accompanied by Malay, when she explained how the lengths of both lines are equal, as can be seen in Excerpt 3.

Excerpt 3

1  T: And “d”? *(pointing at “d” in Picture 1)*
2  Ss: Tak tahu *(don’t know)*
3  T: OK “d” ni cikgu kata dia sepatutnya sama dengan ... *(OK I have said that this “d” is supposed to equal with ...)* *(pointing at “d” in Picture 1)*
4  Ss: Sama dengan tiga *(equal with three)*
5  T: Tiga? Ini tiga sama dengan ... *(Three? This one equal with ...)*
6  S: Bukan, tujuh dekat atas tu *(No, it is seven up there)*
7  T: Yes, this way *(pointing at “d” in Picture 2)*. This way huh ... sebab sambunglah *(because you have to connect)*. OK sebab sini dia mesti sambung sini *(OK because here must be connected to here)*.

*(RMMBYTF2)*

When the students reply in Malay (see Turn 2), Bo continues her conversations in Malay (see Turn 3 and 5), and a mixture (see Turn 7). She asks them the value of “d” in Picture 1 in English, while pointing at that specific area. Then, when the students reply “tak tahu” which means “they don’t know”, she spontaneously changes her language to Malay, in which she reminds her students of her statement earlier, when calculating the same type of solid. The three elements that come into play in this sequence are the picture of the solid, the talk, and the gestures; all of which are used to enable the students to come to the correct understanding. One student gives the correct answer (see Turn 6), and it then allows Bo to proceed with her calculation.
The outcome might be different, or the students might take a longer time to get the correct answer if only spoken and written language were used. The gestures, together with the main language, Malay, appear to play a crucial role in this context.

In another example from her other lesson about “reflection”, Bo prepared pictures and notes about reflection which she pasted on the board. More talk occurred when she explained the definition of “reflection” and the properties of reflection at the beginning of the lesson. In most of the sequences, a lot of hand gestures were used, to refer to every important point of the object or image discussed. For example in a sequence discussing the properties of reflection, talk was based on the written notes that she pasted on the board. Since the notes were in English, she used mainly Malay together with hand gestures to elaborate the notes. Excerpt 4 displays the detail of one sequence from the lesson.

**Excerpt 4**

1. T  
   *Dan* last one *sekali* (*and the last one*), the axis of reflection perpendicular bisector of all the straight lines joining the points of object and image (*reading from the notes on the board*). *OK apa maksud ini?* (*OK what is the meaning of this?*)

2. S  
   ... 

3. T  
   That means, *OK, titik ini ialah objek* (*this point is the object*) (*pointing to a point of the object*), *ini ialah imej* (*this is the image*) (*pointing to a point of the image*).

   *Dua titik ini sepadan ya* (*this two points are corresponded to each other*) (*pointing to the two points*). *OK. Dia akan membahagikan jarak yang sama rata* (*It will devide the lines equally*) (*pointing to both lines*), *dan dia membentuk sudut tepat di tengah-tengah* axis of reflection (and it constitutes a right angle triangle in the middle of the axis of reflection) (*pointing to the axis of reflection*).

   You *nampak* (*Can you see*). *Kalau sini tiga kotak* (*if there are three boxes here*) (*pointing at the length of the object*), *sini pun tiga kotak* (*it is three boxes here as well*) (*pointing at the length of the image*). *Dan bila bertemu di axis of reflection ni, dia berserenjang, bersudut tepat* (*and when met at the axis of reflection, it is*.
perpendicular, it has a right angle triangle) (using her finger to trace the right angle triangle).

(RMMBYTF1)

Turn 3 in Excerpt 4 shows the teacher used Malay to unpack the properties of reflection that she has written on the board. While unpacking, her fingers were busy pointing here and there at the picture, to show the exact location of the point she was referring to (see Figure 8.7).

Similarly here, language, picture, and gesture were combined to explain “the properties of reflection”. As said, Bo used mainly Malay to unpack the English sentences written on the board. By incorporating gesture, it is arguably easier for the students to comprehend as they can see clearly which aspect of the picture is being discussed, compared to a situation where no gesture is used.
Overall, gesture plays a crucial role in both of Bo’s lessons, besides the spoken and written language, and the pictures she prepared. She moved back and forth within the three main elements to discuss “reflections” and “surface area” with her students. Apparently, the movements between natural languages, which are English and Malay, are seen as an important strategy to support students’ understanding.

By using an extended version of Setati et al. (2002) diagram, Figure 8.8 shows the multimodality in Bo’s lessons. Gesture and image were incorporated in every route of the language movements as she moved from one solid to another in discussing the surface area of those solids.
Figure 8.8 Multimodality in Bo’s Lesson
Seow’s Lesson

Seow was the only teacher who managed to use English exclusively in her class. The lesson discussed in this section is her lesson about “solid geometry” in which she had a lot of group work, as well as incorporating multiple modes of representation. At the beginning of the lesson, students were asked to recall different types of solids that they have learnt about before. Then they were given a task to identify the name of each solid that was given to their group, and to find out the geometric properties of each solid by counting the solids’ faces, edges, and vertices. During the group work, the teacher goes from one group to another, to interact with them as well as checking their work. She facilitates them by explaining the difficult part of the task, or approving their answer for each question in the exercise.

In one sequence for instance, the students in one group are unsure whether a cylinder has an edge. By holding the cylinder, Seow shows them the edge (see Picture 1), and gives an analogy that relates to a daily situation (see Figure 8.9). She asks them to imagine that they are standing at the edge of a cylinder, and if they will fall off when they walk further to the end of the edge (see Picture 2). The multiple modes (natural language, 3D object and gesture) employed in this sequence are mediating the students to visualize the situation clearly. They can simply imagine that they are standing at the end of the edge and can fall down if they walk further. It seems that English was used simply as the combination of all elements that helped the students to understand the explanation given by the teacher.
Besides 3D objects and gesture, Seow uses other modes such as an exercise sheet, a table, and the net of each solid. She moves from one mode to another depending on the activities that she has prepared, mostly group work for exercises and whole class for discussion sessions. A table was used to compare the geometric properties of each solid, by identifying the number of faces, edges and vertices of the solids. She draws the table on the board, and selects one student from each group to write down their answer on the board. In the later activity, she guides her students to open up all solids in order to get the net of each solid. The nets are then pasted on the board, which enable the students to see that even similar solids can have a different net (see Figure 8.10). Seow used her finger to point at different nets as a proof that similar solids can have different nets (see Figure 8.11).
Figure 8.10 The students were busy pasting their net on the board

Figure 8.11 Seow is pointing at one of the nets

The 3D solids are also used to show the similarities and differences between solids, and by showing the objects to the whole class, the comparison can be made easily by pointing at the specific property of the solid that is being discussed (see Figure 8.12).
This section has shown the importance of multimodality that was carefully blended in the lesson, particularly to make possible for English to be used dominantly without the need for translation. In regard to the Setati and Adler extended diagram, Figure 8.13 displays the multimodality employed in Seow’s lesson which had helped her to use English only. As mentioned earlier, both parties, that is the teacher and the students, must possess a good competency in English if only English is to be used in the classroom. However, the embodiment of multiple representations as shown in those sequences above has expedited students’ understanding. As shown in the diagram below (Figure 8.13), the language movement involves only the formal spoken and written mathematics, and informal spoken mathematics in the language of instruction. Apart from that, the other modes came into play as part of the package to complete the journey. Arguably, it might be difficult for the teacher to use English exclusively without recourse to modes other than natural language.
Figure 8.13 Multimodality in Seow’s Lesson
8.3 The Role of Multimodality in Supporting Teaching and Learning

The previous sections have unpacked the critical importance of multimodality in the teaching and learning of mathematics and science, especially in bilingual setting. A number of important aspects of multimodality can be gathered from the discussions above.

First, there is the fact that understandings in mathematics and science are inherently multimodal. In mathematics, meaning is carried by a combination of words, visual images, mathematical symbols and gesture, whereas science meaning depends on a combination of words, visual images, embodied understanding and embodied/gestural language, and symbols such as arrows. These aspects were seen as working together in both mathematics and science lessons, supporting translation across languages.

In teaching and learning in a bilingual setting, translating between Malay and English was also aided by other modes, as can be seen in the examples of sequences discussed in the previous sections. The translation was not restricted only between elements of natural language, but also between gesture, artefact, and embodied sense. For instance, in the sequence where Kalsom defined “force” by translating the term from English to Malay, the translation was also accompanied by gesture (see Excerpt 1 below). Particularly in Turn 3, the translation of spoken language from English to Malay involved hand gesturing too whereby the gesture establishes meaning visually.

Excerpt 1

1 T Force ... OK, page fifty-eight ... OK look a note in front of you (reading the notes on the board) ... OK force is a pull or of push of an object ... daya adalah satu push ... apa push? [force is a push ... what is push?]

2 Ss Tarik [pull] ... Tolak [push]

3 T Tolak [push] (showing a sign for pushing with her hand) ... or and pull (showing a sign for pulling with her hand) ... pull apa? [what is pull?]

4 C Tarik [pull]
Another example can be seen in Seow’s lesson (see Figure 8.8 above, and Excerpt 5 below) in explaining whether a cylinder has an edge. She employed multiple modes such as artefact, gesture, and analogy to help the students to think through the answer. The notion of edge that was expressed in English was supported by artefact, gesture and analogy which arguably established meaning visually as well as an embodied sense when asking the students to think of them walking along the edge. The gestural modality used in Turn 1, Excerpt 5 (pointing to the location discussed), plays as a complementary role in the overall construction of the explanation.

**Excerpt 5**

1  T  Cylinder ... yes this is an edge (*pointing to the edge of the cylinder*) ... All right ... Imagine you are standing here (*pointing to a spot at the edge of the cylinder*), if you walk ... if you take a step (*using her index finger to show the movement*) ... will you fall off?

2  Ss  Yes

3  T  Yes ... so this is an edge (*pointing to the edge of the cylinder*) ...
    ... OK

Research on multiple representations recognizes that different representations may constrain, complement, or help construct meaning (Ainsworth, 2006). This research establishes that different representations complement each other in the construction of meaning.

One of the focal points of Vygotsky’s theory of learning is the concept of semiotic mediation. Mediation is the use of a tool to accomplish some action, whereas semiotic refers to the many signs available around us such as language, various systems of counting, algebraic symbol systems, diagrams and maps. From a Vygotskian perspective, learning is inevitably a mediational process where language, and representations and artefacts more generally, are the means by which learners are supported to develop new practices implying new ways of looking at the world.
Rather than serve as illustrative of ideas, these languages are a constituent element in the teaching and learning process (Tytler & Prain, 2013).

In teaching and learning in dual languages classrooms, besides the interplay of multiple representations, the teacher and students need to grapple with the two different systems of natural languages, which contributes to a more complicated situation than has been studied previously with regard to multimodal representational learning. Apart from translating and negotiating the multiples modes of representations, they are also burdened with the busy task of translating and negotiating between the two natural languages that are employed in the classroom. The discussion in this chapter has shown that the movement between English and Malay was always accompanied by other modes such as gestural/embodied language, visual images and artefacts. It is in fact not an easy task for either the teachers or the students to participate in.

On one hand, the teachers were engaged with various responsibilities such as moving between formal and informal English and Malay depending on several circumstances, at the same time incorporating multiple modes of representations alongside the natural languages as determined by the nature of the content, and the need to deliver the content successfully. The multiple tasks that the teachers are required to perform in each lesson put a huge responsibility on them. However, from their responses in the post-lesson interviews, most teachers acknowledged the advantages of incorporating multiple modes of representations in their teaching. Some of the teachers acknowledged that multimodality has supported their teaching, in particular by simplifying what has been delivered through natural language.

Students on the other hand were asked to learn through English, which is a different language from their first language, alongside the national language, Malay, which functioned as a “rescuer” at times when using English was difficult. Most of the time, language used in the classroom was determined by several factors, for instance teachers’ and students’ language competency, and the types of activity organised at that time. Thus, the students’ opportunity to have the freedom in selecting the language that suited them the best was very minimal. They were required to learn through the language that was determined mostly by the teacher. Concurrently, they needed to have the ability to translate and link all the different representations.
employed in the lesson. However, the data shows that while learning in a second language introduces complexity and places strains on the meaning making that influenced the choice of language used, the use of multiple representations in these lessons is a support for these acts of meaning making. They do this through mediating not only between the experience of phenomena and natural language, but also between the dual language resources the teacher and students have access to.

8.4 Summary

As suggested by Kress et al. (2001), multiple modes of representation are part of the process of teaching and learning which need to be given equal consideration to that afforded to natural language. Thus, this chapter has highlighted the importance of multimodality in the teaching and learning mathematics and science which employed more than one language as the language of instruction.

Detailed classroom analyses have shown that every mode combined in the process of teaching and learning has its own contribution to the meaning making process, and together complement the process and help both the teacher and students to teach and learn meaningfully.
CHAPTER 9

Discussion

In the previous chapters, I highlighted how language is used in mathematics and science classes taught in a second or third language. The language used is analysed according to the pattern of language use, the types of interactions, the situational influences on teachers’ and students’ choice of languages, and the multimodality of the teaching practice.

In this chapter, these different analyses are tied together to make sense of the ways that languages were used in those classes. The following sections are organised in relation to the research questions, as shown below:

RQ:  How is language, which includes multiple modes of representations used in mathematics and science classes taught in a second or third language?

SQ1:  What pattern of language use occurs in mathematics and science classes taught in a second or third language?

SQ2:  What is the relationship between the different pattern of language use and types of interactions in mathematics and science classes taught in a second or third language?

SQ3:  What are the situational influences on teachers’ and students’ choice of languages in mathematics and science classes taught in a second or third language?

SQ4:  How do different representations and artefacts support teaching and learning mathematics and science classes taught in a second or third language?
9.1 Pattern of language use

This research was conceptualised and carried out during the period when Malaysia implemented the policy of using English as the language of instruction for mathematics and science subjects in all school levels. Eight mathematics and science teachers from two secondary schools were participated, which involved 15 lessons recorded all together. The schools, teachers, and classes were carefully selected in order to provide data variation but yet to reflect the average school in Malaysia. The data was organised and coded using Transana, a qualitative analysis software package for video and audio data, particularly to deal with a large amount of video data, and to organize video clips into meaningful categories. Interviews and classroom observation data were also used, to generate a holistic understanding of the situation. As an essential step in analysing qualitative data, a coding scheme was developed which comprised of four broad categories related to language use; Classroom Organisation, Language Use, Types of Interaction, and Types of Talk. Classroom Organisation marks the way the class activity was organised, whole class, group work, or individual work. Language Use labels the language used at any particular time whether English, Malay, or a mixture or other languages such as Mandarin or Tamil. Types of Interaction includes of Expository, Teacher Led Interaction and Student Led Interaction, whereas Types of Talk shows Curriculum-related Talk, Organizational Talk, Disciplinary Talk, and Informal Talk for teacher’s talk, and On Task Talk and Off Task Talk for students’ talk. Some common patterns occurred in general with some variation. For instance, only formal English was used in all classes, where almost all lessons were commenced and finished with formal English. In between, English, Malay or a mixture was used in conjunction with types of talk and classroom organisation.

Generally, all lessons began with whole class activity, and then continued with small group or individual work, before returning to whole class activity again. The language pattern for most of the lessons seemed to match the class activity, in which English was dominantly used in whole class activity while Malay and a mixture appeared mainly in the small group or individual sessions. If we go deeper, this pattern was also consistent with the types of talk occurring during the lesson. Out of four types of talk, English was strongly used for content related talk that occurred mainly during the first
half of the lesson. This is closely related to the English resources that were available for the teachers, for example text book, written notes and video. In contrast, Malay was always used for other types of talk, which are organisational, disciplinary and informal talk. At the same time, teachers tended to use Malay when interacting with their students during small group work. Further, Malay was used in situations that required the teachers to go beyond the discussion shown in the text book or written notes.

It seemed that the language used showed a pattern based on the purpose of language use. English, as the language of instruction was only used in formal form, with the support of resources around the teacher. Malay on the other hand, supplemented the function of English in situations when English proved inadequate for meaning generation, mainly because of the teachers’ language facility but also teachers’ perception of the students’ language level. It is universally accepted that understanding in mathematics and science particularly, involves making links between formal language and everyday experience. However in these cases, the imposition of formal conceptual language needed to be supported by the first language talk. The details of these choices are discussed further below.

9.2 Situational Influences on Teachers’ and Students’ Choice of Languages

The analyses have shown that teachers’ and students’ choice of languages were influenced by several factors. The major influence seemed to be the teachers’ language level where language shifting in the classroom was highly dependent on the teachers. In most of the lessons, the usage of English was more restricted to formal terms, mainly with the support of supplied resources. In addition to this, a lot of translation work was done by the teachers that involved formal terms in mathematics and science. Some teachers for instance Kalsom, translated almost every word in English to Malay, almost always restricted to word to word matching. Other teachers used English when referring to textbook or written notes, or indirectly as they were reading text. Arguably, this translation work involved situations where the language demands were minimal and the usage of English was scripted. However, when the demands on their competence were greatest, they resorted to Malay or a mixture. This
occurred particularly at times when they need to elaborate or explain topics that required extended talk and discussion. Several examples can be found from Kalsom’s lesson. For instance, a sequence from her lesson displayed the shifting to Malay when she gave an anecdote of a football player. This was done as part of explaining the concept of “force can change the speed of an object”, using an anecdote of football players accompanied by a diagram.

A rolling ball on a football field can be stopped if a player stops it with their foot. The act of stopping the ball is the type of force given to the ball to change its speed. The language complexity of the story, and its everyday context, seemed to trigger Kalsom’s switch to Malay. Similarly in Bo Yang’s lesson, Malay was used increasingly halfway towards the end of the lesson, particularly when asking questions to the students. In Bo Yang’s case, however, the shifting to Malay was mainly done to reduce the language barrier amongst the students in order to allow them to participate into the whole class discussions.

While learning should be focused through English as the language of instruction, the scaffolding seemed to occur mainly by translation of specific terms rather than through higher level language support. According to the recommendations from the literature, students should be supported to engage in high level conceptual work in English if this is promoted as the language of construction, with an intention is to improve students’ facility with English. However, the restriction to minimal translation around formal terms, and the use of Malay for the more extended discussion and links with everyday experience, restricted the meaning making in English. It seemed that the requirement for meaning making in science and
mathematics was not effectively matched with the expectation that this be conducted through English.

In particular, students were familiar with learning the translated version of mathematics and science terms, as a way of preparing them for their examinations, as well as for the reversal of the language policy which was implemented in 2012. Although the students’ English proficiency played an important role as well in determining language use, teachers’ language proficiency was always dominant in the teachers’ determination of which language is used. The authority that the teachers possessed allowed them to choose the language spontaneously, particularly when their proficiency in English restricted them to continue in English. A concern with students’ language proficiency however was mentioned in the teachers’ interviews when they claimed that they shifted to Malay or a mixture in order to help the students to learn comfortably. According to the teachers, they would rather use Malay or a mixture if that choice of language could benefit their students in learning.

Students on the other hand, had minimal opportunity to choose the language based on their needs. They could only determine the language during group work, while during whole class session they usually followed the teacher’s language, either English or Malay. However, most teachers considered their students’ English proficiency to be the key determinant of language to be used.

Teaching and learning mathematics and science always involves linking formal ideas to students’ experience, and to construct a narrative around ideas that makes sense to students. The language demands involve much more than the minimal, formal terms that make up the conceptual mapping of ideas, but involves narrative that links the meanings of terms to each other and to students’ own experiences and ways of looking at the world. Thus, where there is pressure of language competence in constructing these more complex learning narratives, the language shifts to Malay.

The literature, particularly Setati et al. (2002) suggest different routes of language use to be taken in teaching and learning mathematics and science bilingually. However, the Malaysian classrooms have shown other routes for language use in such cases. The directions of language movements in the classrooms in Malaysia were quite distinct, and opposite from that recommended by Setati et al. (2002). They suggest that each language journey in bilingual mathematics or science in classrooms in South
Africa begins with the informal spoken mathematics or science language in the main language, and ends with the formal written of mathematics or science language in the language of instruction. Variations occur in the recommended pathways through which the language moves, in between the starting to the ending point. For instance, one journey that might be taken begins with the informal spoken mathematics or science language in the main language, moves to informal written language of mathematics and science in the main language, then moves to informal written language of mathematics and science in the language of instruction; before reaching the final destination which is the formal written mathematics and science language in the language of instruction. Another route that is possible might begin with the informal spoken of mathematics or science language in the main language, then moves to informal written mathematics and science language in the language of instruction, before ending with the formal written mathematics and science language in the language of instruction.

On the contrary, mathematics and science classrooms in Malaysia followed the opposite path from the classrooms in South Africa. All lessons seemed to begin either with the formal spoken or written mathematics or science language in the language of instruction, English, and ended with the formal spoken mathematics or science language in the language of instruction. Informal and formal spoken language in the main language was used in between, to embellish and make meaning.

For example, Kalsom’s lesson began with formal written of science language in the language of instruction, moved to formal spoken of science language in the language of instruction, next to formal spoken of science language in the main language, and then moved to informal spoken science language in the main language, before moving back to the formal spoken science language in the language of instruction as the end of the journey (see Figure 7.7).

In Bo’s lesson (Figure 7.8), the language moved from formal spoken mathematics language in the language of instruction, to formal written mathematics language in the language of instruction, then moved to formal spoken mathematics language in the main language, then moved to informal spoken mathematics language in the main language, then moved to informal spoken of mathematics language in the language of
Similarly, the language in Seow’s lesson began with formal spoken mathematics language in the language of instruction, moved to formal written mathematics language in the language of instruction, then moved to informal spoken of mathematics language in the language of instruction, before going back to where it began – formal spoken mathematics language in the language of instruction.

Setati et al. (2002) and the Malaysian language movements discussed above displayed two major differences. The most obvious distinction is that all lessons in Malaysia began and ended with the formal language of the subject in the language of instruction. The second difference was that neither the informal and formal written language of the subject in the main language, nor the informal language of the subject in the language of instruction were ever used in the Malaysian classrooms. To make sense of this, the issue needs to be discussed in a bigger picture which entails the prevailing pedagogy and the curriculum in Malaysia. The prevailing pedagogy in Malaysian classrooms could be seen as one of the determinants of this scenario. Previous research indicates that classrooms in Malaysia are still tied up with teacher centeredness and traditional ways of teaching (Abd. Razak et al, 1996; Jemaah Nazir Sekolah Persekutuan, 1996; Voo, 1996; Wan Mohd Rani, 1999). Even though Malaysia has entered a new era in the curriculum with the introduction of The Malaysian National Syllabus for Secondary School (KBSM) in 1989, many teachers were found to be still influenced by the former curriculum which placed emphasis on rote memorization. Further, the perception that teaching and learning is mainly focused on the purpose of examination was found to play a significant role in determining the way teaching and learning occurs in Malaysian classrooms.

In all lessons involved in this research, teacher-centred instruction seemed to be the dominant strategy compared to a student-centred teaching style. Expository and Teacher Led Interaction dominated the Types of Interaction category in every keyword sequence map discussed in Chapter 6 demonstrating that all lessons employed a predominantly teacher-centred strategy. As discussed in the earlier chapter, teachers in Malaysia are required to complete a set number of topics in a specific time. This constitutes a “busy curriculum” with teachers obliged to conduct
tests and examinations at a given time as part of the students’ assessment needs. With all these pressures on the teachers, it is arguably challenging for them to organise class activity that can provide the possibility for students to engage in more discussion, or to give their students more space to express their own ideas either in their own language, or in the language of instruction.

Most teachers practised a kind of formal pedagogy; mainly to introduce the key formal terms in a topic, and to have discussions around issues that were mainly restricted to resources in English that has been provided to them. Although the English language resources are dealing particularly with formal concepts in high level language, and need to be unpacked in a more informal way for deeper understanding, this phase was unlikely to occur in those lessons either in Malay or in English, due to time constraints and the prevailing pedagogical traditions arising from this as well as to restrictions in language proficiency. Students’ understanding is assessed mainly from their performance in the tests and examinations given to them at the end of each topic.

9.3 Pedagogy and the Broader Pattern of Language

By focusing on language and pedagogy, this section attempts to extend and interpret the discussion based on the research question in the previous sections. Based on the constructivist paradigm, people construct their own understanding and knowledge of the world through experiencing and reflecting on those experiences. Learning then is viewed as a way to encourage students to use active techniques in order for them to create more knowledge. Following that, they need to reflect and talk about what they are doing and how their understanding is changing. Thus, a classroom should provide opportunities for knowledge to be co-constructed. In this paradigm, the teacher functions more as a facilitator to encourage and promote active interaction, as well as a source of curriculum knowledge in the classroom.

In Malaysian classrooms however, the students come from multiple ethnic communities and religions. The three biggest races are Malay, Chinese, and Indian, besides other minority ethnic groups. The diverse backgrounds of students in a classroom then require a modified lens on the constructivist paradigm, which in some aspects is in contrast to the culture and practice in the Malaysian classrooms.
Education from the Malay perspective is strongly shaped by Islamic teaching. Islamic teachings encourage learners to seek knowledge as according to the teachings of Islam, which hold that seeking knowledge is a great act of worship that leads one to the path of paradise. A good learner then, is a person who has a positive attitude towards learning. If we look from the viewpoint of Islam, a teacher is considered to be a person of equal standing as parents. Parents in Islamic view hold a very high rank where they must be obeyed and respected at any circumstances unless they ask for something that is contradictory to the Muslim’s beliefs. Therefore, a good student is one who is receptive of the teacher’s knowledge and wisdom. Whenever the students’ opinion or perspective is different from the teacher, the differences must be expressed in a proper manner. Likewise, Chinese schema of education also portrays a different perspective from the “western” framework of constructivism. Based on the philosophy of Confucianism, teachers are regarded as transmitters of moral virtues and harmony (Bee Eng and Kumar, 2009). They need to be highly respected; the students are not expected to interact freely with the teachers mainly because their status is not equal.

When discussing the pedagogy in Malaysian classrooms, all perspectives discussed above need to be considered as part of the background to the pedagogy practised. In regard to the prevailing pedagogy in the classrooms, students were given limited opportunity to express complex thoughts either in English or Malay. Talk in the classroom was dominated by the teacher, with the students cast as passive learners who usually responded to closed questions in chorus. Considering the Malay and Chinese schema of education discussed earlier, the tradition and culture of the students and teachers are likely to play a huge role in shaping the pedagogy. Either from the Malay or Chinese perspective, students are encouraged to take active participation in discussion but it needs to be expressed in an appropriate manner. Within this tradition, it is indeed possible to have a lot of student input as well as to guide their understanding to a deeper level. However, only a few lessons demonstrated active students’ participation in oral academic discussion, possibly as a result of a combination of the constraints discussed earlier, together with these cultural presumptions concerning teacher-student relations.
9.4 Representations and Artefacts to Support Teaching and Learning

In previous research into bilingual classroom language use, focus has been given to the natural language as an essential aspect in teaching and learning. However, there has been increasing interest in the multimodal nature of learning, particularly in mathematics and science (Lemke, 1990; Kress, 2003; Tytler et al. 2013). Meaning is carried through diagrams, video, photographs, 3D models, and artefacts as well as words. Mathematics and science are subjects that are naturally multimodal, in which understanding depends on combination of multiple modes of representations. Words, visual images, mathematical symbols, gesture, artefact, embodied understanding and embodied/gestural language, and symbols such as arrows are amongst the elements that contribute to meaning making in mathematics and science. As mentioned earlier, translation was a common strategy applied in bilingual mathematics and science classes in Malaysia to ensure the students received fullest understanding of the teaching and learning. More importantly, the meaning making and translating process was aided by a range of modes such as gesture, visual and mathematical representations, artefacts and embodied experiences, as well as natural language. In the translation process evident in most lessons, the analysis has clearly shown how these other modes support the process.

At the time when the data was collected, English was the language of instruction for mathematics and science subjects in all primary and secondary governments’ schools in Malaysia, although English is not a first language to either the students or the teachers. Thus, the negotiation of language in those classrooms is complicated, involving not only multiple natural languages but also multiple modes of representations.

In mathematics lessons, the combination of words, visual images, mathematical symbols and gesture has complemented each other’s role to support meaning making. The multiple modes of representations played a significant role in mediating teachers and students in their teaching and learning journey. For example, Bo Yang’s lesson has displayed evidences of how the multiple modes of representations, especially diagrams and gesture, became part of the essential elements in the process of meaning
making. Likewise, science lessons also depended on multiple modes of representations, which has been discussed in depth particularly in Kalsom’s lesson. Artefacts, 3D objects, video, gestures and anecdotes were part of the representations orchestrated in her lesson, which helped both the teacher and the students to achieve better understanding towards the topic, and supported the interpretation and translation processes involving the main language and language of instruction.

As shown earlier, the multimodality nature of teaching and learning in mathematics and science might be envisaged to work in a modification of the Setati and Adler diagram (see Figures 7.4). In terms of capturing the development of meaning, the language movements shown in the diagram cannot be considered comprehensive without the inclusion of the multi modal representations elements. Figures 8.4, 8.7 and 8.12 show how the translation pathways between the main language and language of instruction are in each case supported by a range of multimodal resources. Vygotskian notions of mediation, and the role of language in coming to know (Vygotsky, 1986) are important in interpreting this process. At the end, mathematical or scientific meaning is generated as a complex mix of not only English and Malay natural language, but also the web of representational systems through which mathematics and science knowledge is expressed.

The inclusion of the multimodal representations in the modified diagrams as discussed in depth in the previous chapter can be seen as an innovative part of the study. It is in fact breaking new ground in investigating the interactions between multi modal representations and language negotiation, in the teaching and learning of mathematics and science in a bilingual setting.
CHAPTER 10

Conclusion

This thesis has examined the role of language in the teaching and learning of mathematics and science in a second or third language, exclusively focusing on the experience of Malaysia. As a multilingual, multiracial and multicultural country, English in Malaysia is considered as language second only to Malay language, the official language of Malaysia. In the education system, the role of English has undergone many phases in this country since Malaysia gained its independence in 1957 until now. From the language of instruction at the beginning of the independence period, to a compulsory subject, to then becoming also the language of instruction for mathematics and science until 2012. However since 2013, the language of instruction of mathematics and science has reverted to Malay, and English remains as a compulsory subject in school, as well as a second or third language for the majority of Malaysians.

The policy of teaching and learning of mathematics and science in English (ETeMS) was implemented for approximately 10 years, where it was introduced in 2003 until the abolishment of the policy in 2012. Within that period, there has been a considerable amount of research reported on issues and challenges of the implementation of the policy. Upon announcing the abolition of the ETeMS policy, Malaysia’s Education Minister mentioned a ministerial study showing that the ETeMS had not been implemented as intended. Less than five percent of the total classes in 7,495 primary schools fully used English for mathematics and science, and less than nine percent out of 2,192 secondary schools used English fully. Further, interviews with students revealed that they found it hard to understand mathematics and science in English. Ultimately, this problem did not just occur in rural areas but in the cities as well (“Final PPSMI batch to continue in English”, 2011). With the reversal to Malay for mathematics and science, Malaysia has re-established the position of Malay as the official and national language of the country, as well as the language of instruction for all subjects in all school levels, as it had been since the 1980s. In many other countries however, mathematics and science are still taught and
learned in a language that is different from the teachers’ and students’ first language. This study has investigated the unique experience of Malaysia in adopting the policy of teaching and learning mathematics and science in English, which is not a first language to either the teachers or the students. Malaysia’s experience can serve as a valuable resource for bilingual education systems globally, particularly for countries practising a similar policy.

10.1 Contribution to the Literature

The significance of this research lies in its contribution to understanding the role of language in teaching and learning mathematics and science in a bilingual setting. One of the main contributions is the identification of prevailing patterns of language use under the conditions present in Malaysia. As the language of instruction, the data revealed the usage of English was restricted to formal types of conversation only, mainly with the support of resources available which were all in English. All other transactions, particularly informal teacher-students talk occurred in Malay. Most importantly, the shifting to Malay seemed to happen at times when the demands for language were high, most often when links were needed to everyday examples or otherwise to students’ contexts. In order to establish meaning in the learning of mathematics and science, the role of language is central and therefore, whichever language that can best scaffold meaning making will be chosen to fulfil the task.

By comparing the Setati et al. (2002) recommended pathways of languages use in the teaching and learning mathematics and science bilingually, this study showed that practice in Malaysia followed different routes and movements. English was used without many difficulties mostly at the beginning and the end of a lesson, whereas Malay and a mixture dominated most of the talk in between. Teachers seemed to depend on the resources provided to them in order to use English as the medium of instruction. In other words, the usage of English was mainly scripted, as well as restricted. However, the teachers had to shift their language to Malay or a mixture whenever the situations required them to talk about more complex ideas, which usually occurred when connecting the discussion with the students’ daily experiences.

As discussed earlier, the pathways followed by Malaysian classrooms were in contrast to those suggested in the literature. The resources provided by the government which
were in English only seemed to play a huge role in determining the way the teachers and students use language. In order to “comply with the regulations”, the teachers struggled to use English as much as possible in their classes, and this is demonstrated in the pathways of their language use. They managed to use English fully whenever they were referring to the resources given to them, but shifted to Malay or a mixture in the middle of the process through translating and reinforcing, before finishing their lesson in English again. Arguably, they have to go through a difficult process which resulted from the obligation to use only English in teaching and learning.

The literature (Setati et al., 2002) suggests that teaching and learning should be built from the main language, Malay, and move towards formal English, as the final destination in a bilingual teaching and learning process. The main objective is for the students to be able to use the formal spoken and written language of the subject in the language of instruction. This process provides some space and opportunities for the teachers and students to become familiar with the language, as well as to link their experiences and understanding with the topic discussed in each lesson. Therefore, this research suggests more flexible packaged resources should be provided to the teachers and students to enable them to choose the best packages that suit their competence and level of understanding. They should be provided with some exemplars that can guide them to move from Malay to English according to their capability and competency in English. In other words, students should be scaffolded through dual language use to learn through disciplinary studies, giving priority to the coordination of conceptual understanding and language competence.

This study also contributes to understandings concerning multimodal representational work in teaching and learning mathematics and science bilingually. The importance of multimodality from the perspective of teachers and students is becoming a powerful focus of exploration in the teaching and learning literature. In recent years, research has been focused on multimodal practice particularly in the teaching and learning of science, as well as mathematics, and education in general. For instance, Ainsworth (2006; 2008) and Gilbert (2005), concentrate on the support of students’ interpretation of representations, Tytler et al. (2013) and Carolan, Prain & Waldrip (2008) look at the role of representation construction in learning science. In social semiotics, Jewit (2007), and Kress & Van Leeuwen (2006) establish the central role of multiple and
multimodal representational practices in teachers’ classroom activity. Yet, the recognition of multimodality is still a gap in research into the teaching and learning of mathematics and science bilingually, especially looking at the role of multiple representations in supporting and assisting teachers and students. This study has demonstrated the significance of multimodality in the teaching and learning of mathematics and science in classes that use a second or third language. The interaction between multimodal representations and language negotiation shown in this study presents a new dimension in the area of bilingual studies as well as in the teaching and learning of mathematics and science.

From the viewpoint of Vygotsky’ mediation of learning, teachers in this study should play the role of mediator in guiding the students to use a higher level of language in order to reach deeper understanding. When the usage of English was scripted and restricted, the level of understanding achieved is arguably at a surface level and far from the expected level. Students need to be given time and space to develop their English through guided interaction and active participation in small group discussions. More importantly, the students need to be assisted to establish their content understanding as a basis of producing the formal language of the subject in the language of instruction. Further, this study establishes the importance of multiple representations which become critically important tools in learning mathematics and science, particularly in classes that employ more than one language.

The study is also significant in the way it brings to view the need for a more complex and nuanced view of language and its tense relationship with pedagogy, and meaning making. Following Gee (1990) and Lemke (1990) the patterns and language relationships identified in the thesis demonstrate that language is not simply about speech patterns and multi modal representational work but about the establishment of meaning, and the power relations inherent in the management of meaning construction in classrooms. The central concerns of the thesis are not only about the encoded aspects of language and way teachers moved between them but that language is about performance and the relation of this to others and to the context of the classroom. The demonstration that teachers' choice of language was conditioned by the need to convey complexities of meaning is a powerful example of the reflexive relationship between language, meaning and power; a relationship that was
unrecognised in the framing of the Malaysian language policy but was critical in framing its application in practice.

10.2 Implications for the Teaching of Mathematics and Science in English

The implementation of the Malaysian policy of teaching and learning of mathematics and science in English is seen as “a decade of failure from various angles” (Ha, Kho & Chng, 2013). The decision for implementing such policy itself was considered as “less consultative” where it was simply announced through the media by the then Prime Minister, Dr. Mahathir Mohamed (Gill, 2007). Issues such as the viability of the policy and the ability to implement it were parts of the reason for many academics to disapprove the policy, especially since “the national language is the main medium of instruction for the national education system” is still stated in the National Education policy (Gill, 2006). Apart from that, teachers were not qualified to conduct content based learning in English particularly after 30 years of cultivating Malay language as the language of instruction. Thus, many schools continued to deliver both subjects in the Malay language. Furthermore, the policy was implemented approximately six months from the announcement date which restricted the possibility of proper preparations. According to the Ministry of Education Malaysia (2010), this policy has lead to a widening gap in academic performance for both subjects between the rural and urban areas.

This study has demonstrated in some detail the pedagogical implications of the policy and pointed to some of the consequences for learning. It has also drawn attention to some significant issues around the implementation of a policy of bilingual teaching in mathematics and science, and by extension more generally. A number of implications from the study for implementing bilingual mathematics and science are discussed next.

First, the data revealed that there is a need to attend to pedagogy and not simply language competence. The materials need to be structured with pedagogical model in mind, and not simply be in English. There should be some rooms for the teachers and students to go back and forth in their own language to develop deeper understanding
of the subjects, before completing their task in the language of instruction. This is particularly so when there are issues of language competence of teachers.

Secondly, teaching and learning in a language that is different from the first language, particularly of mathematics and science, is globally considered to be challenging and complicated. As a result, many countries practicing this policy are encouraging teachers and students to use their first language as a bridging strategy before achieving the mathematics or science language in the language of instruction (Martin, 1996; Probyn, 2006). The process of teaching and learning then should consume a longer time whereby the students are given extra time to convey their own understanding in the language of instruction. Thus, the implementation of a policy in Malaysia which discouraged languages other than English to be used in the classroom has resulted in students’ restricted usage of English, as well as minimal students-teacher academic conversation in general. Students responded mostly in chorus, as if they were lacking in confidence to express their view in public, arguably because of perceived language incompetence. To overcome this issue, it is recommended that teachers and students are given flexibility in choosing the language to be used at some stage of the teaching and learning process that best suited their language level. At the same time, teachers should also be given some authority in planning the topics and duration of each topic to be taught since time constraints seemed to be one of the barriers for the policy to become successful.

Another implication arising from this study is the importance of looking at teachers’ and students’ readiness to undergo the policy. Teachers as the most important stakeholders in this issue should be given sufficient time to prepare themselves for the policy changes. In the case of Malaysia, most of the teachers involved were teachers who were trained to teach the subject in Malay. To enable them to teach effectively in their second or third language would consume time and effort, as well as appropriate in-service training. Thus, there is a need to improve the training provided by the government such as ETeMS and Buddy Support Systems, especially in terms of the duration of the course which would need to be an ongoing program rather than a one-time course. Particularly teachers with low language competence, they should be provided with ongoing support to equip them with the academic language of the
subject, as well as to enhance their confidence in employing the language in their teaching.

Students on the other hand need to be given extra support to improve their language competency. Apart from allowing them to use their first language at some stage of their learning process, they should be provided with non-pressurised environments where they have for instance a longer time to respond to teacher’s question, and more group discussions in order for them to develop their language ability.

10.3 Limitations of the study

It is important to note the methodological limitations of this study involved in this thesis. As discussed earlier, this research aims to give insight into an issue, with a specific purpose to generate rich descriptions of language interactions, rather than aiming for the quantity of interactions that occur in the classrooms. However, the conclusions from this study are limited as there may be questions regarding the small numbers of representatives in this research. Future studies would benefit from the use of a larger sample that can include more varieties of students and schools.

Another important limitation of this study is the ambiguous context in which the study was done, when the government of Malaysia decided to revert the policy to Malay as the language of instruction. Considerable discussions took place, concerning the relevance of the topic still, before coming to the conclusion that this topic remains significant both nationally and globally.
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Appendix 1

INTERVIEW QUESTIONS

TEACHER INTERVIEW

PRE-LESSON INTERVIEW

PART 1 – BACKGROUND INFORMATION

To begin with, I’d like to establish some facts about your teaching background.

How long have you been teaching at lower secondary level?

How many years have you taught at this grade level?

How many years at this school?

How long have you been teaching altogether?

Is your teaching option maths/science? If not, what is your teaching option?

Tell me a bit about your English language skills.

PART 2 – LESSON AND CLASSROOM CONTEXT

Can you tell me about your plan for the next two lessons?

What is the topic for each lesson?

What are the goals for each lesson?

What do you hope the students will learn in these lessons?

What types of activities will there be?

Whole class instruction, group instruction, individual problem solving, silent reading

What materials will be used?

textbook, model, web site, video, courseware DVDs
Do you have language goals for these lessons?

If yes, what are those goals?

How do you hope to achieve these goals?

How would you describe the students’ participation in this particular class?

Active? Verbal? Do they ask many questions?

How would you rate students’ level of Maths/science?

How would this compare with other classes?

How would you rate their level of English?

How would this compare with other classes?

How do your students use English in your class?

To what extent do students use English in your class?

always? most of the time? sometimes?

What language do your students tend to use to

answer a question?

ask a question?

answer as a whole class?

talking in their group?

tell a story about their experience?

How do you guide the students in terms of their responses?

Do students from different ethnic groups make different choices of language?

answering a question, asking a question, answering as a whole class, talking in their group, telling a story about their experience?

Do you use language differently when working with students from different ethnic groups?

PART 3 – TEACHING AND LEARNING MATHEMATICS AND SCIENCE IN ENGLISH

How long have you been teaching this subject in English?
How long have you taught this subject in Malay?

Can you talk a bit about your experience of teaching this subject in English?

What languages do you use in teaching this subject?

When do you use them and why?

Do you sometimes use a mixture of languages in your teaching?

When and why does this tend to happen?

Is this a deliberate teaching strategy that you use?

How do you think this helps your students?

Can you tell me about some of the opportunities and challenges of teaching this subject in English?

How are these different from teaching this subject in Malay?

What other differences are there between teaching maths/science in Malay?

stories, discussion, etc

What types of in-service programs have you been involved in since you started to teach this subject in English?

English for the Teaching of Mathematics and Science (ETeMS), Buddy System, Conversion Course

What types of in-service programs would you have liked to have had to help you teach this subject in English?

POST-LESSON INTERVIEW

In a minute, I am going to show you some bits from the video-recording of your maths/science lessons. I will then ask you some questions related on those particular parts of the lessons.

Before we start, however, I’d just like to ask you a few questions about the lesson in general.
PART 1 – ABOUT THE LESSONS IN GENERAL

Can you talk a bit about the two lessons?

How do you feel they went?

Did they go as you had hoped?

To what extent do you think these lessons illustrate your usual practice?

PART 2 – QUESTIONS ABOUT EACH VIDEO EXTRACT

Could you tell me a bit about what was happening at this particular moment?

What you were doing?

Classroom management, explaining concepts, demonstrating skills, etc

What were the students doing?

Listening, answering a question, talking, working on their own, etc

I notice that you were using English/Malay/a mixture at this time.

Can you tell me a bit more about why you were doing this?

paraphrasing, negotiating, translating, etc

Is this typical of the way you use English/Malay/a mixture in your maths/science classes?

Why do you use English/Malay/a mixture in this way?

Have you always taught in this way?

Why do you think this approach is helpful for your students?

Are there any aspects of this that are problematic for you students?

Is there anything else you would like to tell me about this event?

PART 3 – ENGLISH AS THE MEDIUM OF INSTRUCTION

How is students’ learning in maths/science affected by the use of English as the medium of instruction?

Do you think that your students have any difficulties in learning maths/science in English?
If yes, what sort of difficulties do they encounter?

Understanding, spoken, written, etc

Can you elaborate on these?

What sort of strategies do the students use to deal with these difficulties?

Do you think that your students have any advantages in learning maths/science in English?

Could you tell me a bit about the strategies you and your students use in your classroom to help them understand maths/science?

How do you think your students’ learning in maths/science, is affected by the differences between everyday language and the academic language of maths/science?

Do you think that your students have any difficulties in dealing with this aspect?

If yes, what sort of strategies do you and your students employ to overcome those difficulties?

How do you think your students’ learning in maths/science is affected by the multiple forms of representations that are used such as tables, graphs, diagrams, models etc?

Do you think dealing with these multiple representations can support your students’ learning in English? Can you explain?

Do you think that your students have any difficulties in dealing with these multiple representations?

If yes, what sort of strategies do you and your students employ to overcome these difficulties?

What constrains do the curriculum and assessment place on effective learning of mathematics and science in English?

PART 4 – CHANGES OF POLICY IN 2012

When the policy changes back to teaching maths and science in English in 2012, do you think your teaching will be different?

If yes, how?

Will that affect the quality of student learning of maths/science?

If yes, how?
PART 5 – ENDING THE INTERVIEW

Before we conclude, is there anything else that you want to tell me about?

Thank you for your help.
STUDENT GROUP INTERVIEW

In a minute, I am going to show you some bits from the video-recording of your maths/science lesson. I will then ask you some questions related on those particular parts of the lesson.

Before we start, however, I’d just like to ask you a few questions about maths/science at school.

PART 1 – WARM-UP QUESTIONS

What is your favourite subject?

How do you feel about maths/science?

Do you like maths/science?

What do you like/not like about it?

Did you find the lesson interesting?

Was that lesson typical?

In what ways was this lesson different from usual?

PART 2 - QUESTIONS RELATED TO THE VIDEO PLAYBACK

Could you describe what is happening in that particular moment?

What were you doing?

Listening, answering a question, talking, working on your own, etc

What was your teacher doing?

Talking to the whole class, listening to the answer to a question talking to your group, demonstrating how to do something, etc

I notice that your teacher was using English/Malay/a mixture at this time.

Does your teacher usually do this?

Why do you think he/she was doing this?

I notice that you were using English/Malay/ a mixture at this time.
Do you usually do this?
  
  When would you do this?
  
  Why would you do this?
  
  Tell me more about it.

Are there any problems with working in this way?

Do you want to tell me anything else about this particular moment in the lesson?

Move on to the next video extract.

PART 3 – ENGLISH PROFICIENCY

How good do you think your English is?
  
  What makes you think that?

Do you think your level of English affects your learning of maths/science?
  
  How does it affect your learning?
  
  Why do you think so?

Do you use English other than in Maths/Science and English classes?
  
  If yes, where, when, how often?
  
  Why do you use English in these case?

Apart from your maths/science text book, do you ever read anything in English?
  
  If yes, what do you read?

PART 4 – LEARNING IN ENGLISH

Do you like learning maths/science in English?
  
  Why? Why not?

Do you have any difficulties in using English as the medium of instruction?
  
  If yes, could you tell me more about that?
  
  What strategies do you use to deal with those difficulties?

Do you use languages other than English during lessons?
  
  If yes, what other languages do you use?
Could you give me examples of when and why you use that language in learning maths/science?

How do you think this can help you understand maths/science better?

What language do you use:

to interact with your teacher?

to interact with your friends/in group discussions?

in your written work?

to do your homework?

in your tests/examinations?

Is it different in maths/science classes that use English, if compared to other subjects such as History, Geography and Music Education classes that use Malay?

If yes, how is it different?

discussions, questions, stories

PART 5 – CHANGES OF POLICY IN 2012

Do you think the changes in policy so that maths and science will no longer be taught in English will change the way you learn maths/science?

Why? Why not?

How?

PART 6 – ENDING THE INTERVIEW

Before we conclude, is there anything else that you want to tell me about?

Thank you for your help.