What are the factors that influence the frequency of mathematics register in one linguistic code than in another?

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This study is to draw attention to some of the significant factors that have increased the frequency of English mathematics register by both classroom teacher and learners in a bilingual Farsi/English mathematics lesson. The extent to which code-switching occurs does depend on the speaker's linguistic proficiency. The students who were more fluent in English were more likely to respond in English, and the ones who were more fluent in Farsi responded in Farsi most of the time. This study reveals not only that being communicative competence in a particular language can dominate the conversation in that specific language, but also how the written mode can influence the verbal counterpart.

Keywords: heritage bilingual learners, code-switching, mathematics register.

Introduction and background of the study

Throughout my classroom observation in a bilingual (Farsi and English) mathematics lesson in a weekend complementary school, I observed that English and Farsi are valued equally and are used interchangeably among learners and the classroom teacher, for example in group discussions. I argue that this complementary school is a bilingual community of practice (Creese, Bhatt and Martin 2007) where the teacher's and learners' language choices contributed to the negotiation of meanings in the mathematics lessons. Complementary schools are community education institutions (Creese, Bhatt and Martin 2007) where both learners and teachers have a greater access to the range of linguistic resources which "seem to offer a window onto a multilingual England [which is] often hidden from the view of policy makers in mainstream education" (Blackledge and Creese 2010, 11).

Analysis of the incidents

During the bilingual talk in this Iranian complementary school mathematics classroom, there appeared to be a high degree of code-borrowing in Farsi from the English mathematics register. Code-borrowing is often referred to as an intersection of single words or short phrases within a sentence in another language (Rasul 2009). Mathematical operations and technical terms such as 'times', 'to the power of', 'squared' as well as both cardinal and ordinal numbers were likely to be in English. In other words, the English mathematics register seems to take over from the Farsi mathematics register on these occasions. The English language seemed to pervade the technical terms and expressions within a mathematical domain and Farsi was left to encompass the vernacular form of communication.

Below are some different examples from my fieldnotes which illustrate some examples of code-borrowing where English words are used for mathematical terms. In my transcript conventions, T = Teacher, B = Boy, G = Girl, [→] = my comments and translation, *Italics* = Farsi transliterated into English, Normal font = English language.

1) T1: 'Three cube' *mishe chand*?
   [What is three cubed?]
2) *B2:* *khob, man* 'take away' kardam 'two' *ra as* 'eight'
   [Well, I took away two from eight]
3) *G3:* *bebakhsid, ino bekham* 'inverse' *bekonam, chetori anjam bedam*?
   [Sorry, how can I inverse this one?]
4) T1: *oon* 'two prime numbers' *ha chi hastand ke* 'product' *eshoon mishe* 'ninety-one'?
   [What are the two prime numbers whose product is ninety-one?]
5) T2: *ki midoone esme in* 'angle' *chiye? In che no* 'angle' *hast? Chiye bacheha?* [Everyone says] 'reflex angle'.
   [Does anybody know what is the name of this angle? What kind of angle is this? What is it guys? 'Reflex angle'.]

I have obtained fieldnotes from 16 hours of classroom observation, interactional data from video recordings (12 hours) and interview transcripts. All qualitative data for the purpose of analysis can be coded and manipulated quantitatively (if necessary) in a variety of ways (Trochim 2006). Quantitative descriptive analysis is an act of recognising features of the text quantitatively. By using this method, I could identify the proportion of Farsi or English mathematics register in a recorded conversation in a bilingual lesson. I randomly chose a 45 minute video excerpt from a bilingual mathematics classroom with English text and numerals and identified the ratio between the English and Farsi versions of number words, other technical mathematical terminologies and ordinary speech (see figure 1).

Figure1:

A bilingual mathematics lesson at the complementary school with only English numerals						
English number words	Farsi number words	Mathematical operations in English	Mathematical operations in Farsi	Ordinary English	Ordinary Farsi	Total number of words
11.5%	1%	7%	0.2%	45%	35.3%	100%
284	21	175	4	1104	847	2455

In that specific bilingual classroom, Farsi number words and technical register constituted just over one percent of the classroom talk whereas English mathematics register including number words constructed 18.5% of the total bilingual talk. This imbalance between the technical registers was not reflected on the vernacular usage of language. The difference of using the vernacular form of language was not as significant as it was for the technical ones. Farsi and English in this lesson appeared to be in a diglossic relation (García 2009), where there are functional differentiations in language usage.

The level of a heritage bilingual learner's linguistic repertoire

Through my classroom observation, ethnographic fieldnotes and video recordings in the complementary school, I became aware that British-Iranian learners have different proficiencies in their linguistic repertoires. They all have learned English/Farsi through different sources (e.g. some at home with their parents and others in an institutional setting) and at different times in their lives. Language acquisition for native speakers starts at home, and most of the language skills are completed at a certain age, whereas for heritage speakers the level of language competency and literacy is not fixed and varies from one person to another (Sedighi 2010).

My research participants had different 'linguistic proficiencies' which they have acquired in various 'age groups' and 'motivational backgrounds' with respect to acquiring their desired language proficiencies. Proficiency in a language affects the ability to solve problems (Saxe 1988) and one's proficiency in a language can be identified and reflected in their daily recitations routines through, for example, one's exposure to media sources or their engagement with printed media. Another challenge for Persian heritage bilingual instruction is lack of suitable textbooks and printed materials (Sedighi 2010). The lack of inadequate bilingual mathematics textbooks and materials creates a tension to teach mathematics bilingually, where the dominant written mode influences the tendency to speak in that specific language. Therefore due to the lack of appropriate material used in a bilingual weekend school, English textbooks which are taught at mainstream schools have substituted for the bilingual (English and Farsi) textbooks.

In one of my video recordings (13/03/2010, 24:15), I became aware of a possible pattern and trigger to code-switching, whereby someone who is communicative competence in a linguistic code tended to switch the ongoing flow of classroom talk to that particular linguistic code. In one specific lesson, teacher (T1) and learners were engaged with a question to find an unknown angle which was drawn on the whiteboard. B3, for whom Farsi is his most dominant language, described the process of how he has obtained a numerical value for the unknown angle in Farsi. When B3's explanation finished, B4, for whom Farsi is his fourth and least dominant language, took his turn. B4 switched away from Farsi mathematics register and said "*aslant* angle-*es* acute angle *hast*. Acute, *kamtar as* ninety degree *bayad bashe*" [That angle is an acute angle. It has to be less than 90 degrees because it is an acute angle]. B4 has drawn across his linguistic resources and as a result he engages with a wider audience (Blackledge and Creese 2010). Moreover, it is in the bilingualism of the lesson that the message is conveyed (in two languages).

Every learner enters this weekend bilingual school with "different degrees of language competence. This could influence how much children benefit from mathematics instruction" (Saxe 1988, 47). In general it could be possible that heritage bilingual learners' inability to express certain lexical or technical vocabulary could cause to code-switch (Polinsky 2008) or code-mix (Rasul 2009) to manage the problem of 'lexical access and retrieval' (Polinsky 2008).

When and why do learners switch to English when they are confronted with mathematics register?

In the examples that I have provided in the 'analysis of the incidents section', English mathematics register was used throughout the whole conversation during bilingual lessons and many other number words were expressed through the medium of English by both learners and teachers. Farrugia (2006) found that a great deal of interchanging between Maltese to English in Maltese mathematics classrooms is as a result of stating subject-specific terms or mathematics register. The Maltese mathematics register has not been developed as much as the English mathematics register. Moreover, sometimes the Maltese equivalent for technical mathematical terms does not actually exist, as in the case of the mathematical expression 'square root' (Farrugia 2009) and that is when and why English is employed by interlocutors in a mathematical discourse.

Farsi unlike many other languages such as Setswana (Adler 2001), Maltese (Farrugia 2006), Somali (Staats 2009) and Chichewa (Kazima 2007), has an extensive mathematics register. Farsi at one stage “was a purely Indo-European language” (Menninger 1969, 116) and most of the mathematical registers that are employed in English language nowadays are derived from Latin, Greek and Indo-European languages (Schwartzman 1994). There are at least a few equivalents in Farsi for ‘multiplication’, ‘hypotenuse’, ‘perpendicular’, ‘exponential’, etc., and there exists a full system of number words in Farsi. This code-switching and code-borrowing has not come about due to Farsi’s lack of a mathematics register.

Research by Jones and Martin-Jones (2004) has shown that a bilingual (Welsh and English) teacher in a mathematics classroom was observed to switch from Welsh to English when referring to numbers and calculations. The frequent occurrence of the direction of switch from Welsh to English can be seen as a “sociolinguistic traces of a period when all children learned mathematics through the medium of English and when English predominated in the financial transactions of adults” (ibid, 62).

On a different ground, Clarkson (2006, 212) has shown even with competent bilinguals who had relatively high competencies in both their languages (English and Vietnamese), the nature of code-switching in their mathematics lessons “appeared to be largely unconscious and unplanned”.

This evidence led me to accept that the lack of register in Farsi was not the main trigger to switch from one linguistic code to another. Going back through my fieldnotes and video recordings, unexpectedly I realised that all numbers on the whiteboard were written in one code, English, which perhaps influenced the same verbal code. Questions and instructions on the paper were all written in the medium of English, including homework papers. This fact led me to believe that the written system could have had an influence on the spoken counterpart.

Further investigation and results of the study

Farsi numerals are written completely differently in comparison to the numerals that are employed in England known as ‘Arabic numerals’. For example, ‘72 ÷ 2 + 50’ is in the form of ‘۷۲ ÷ ۲ + ۵۰’in Farsi. It is ironic that the so-called Arabic numerals are not widely employed in the most Arabic countries (Pimm 1987): instead what is employed is more or less the same as Farsi numerals. Therefore, not to confuse ourselves, I will use Farsi numerals to refer to numerals that are employed in Iran and ‘English numerals’ to refer to the numerals that are employed here in the UK.

I was curious to know whether solving a series of arithmetic questions using different numerals, namely English and Farsi numerals could influence the correspondent verbal counterparts. I followed a key participant in his home environment and examined to what extent a written mode influenced the spoken form in that specific linguistic code. I presented him with two papers. The first paper was written purely in English, including the numerals. In the second paper, both the instructions and the numerals were written in Farsi. I then asked him to say out loud the ways in which he solved the questions (see Figure 2 for English and Figure 3 for Farsi).

Figure 2:

Solving arithmetic through the medium of English with English numerals only

English number words	Farsi number words	Mathematical operations in English	Mathematical operations in Farsi	Ordinary English	Ordinary Farsi	Total number of words
31	0	16	0	0	0	47

Figure 3:

Solving arithmetic through the medium of Farsi with Farsi numerals only						
English number words	Farsi number words	Mathematical operations in English	Mathematical operations in Farsi	Ordinary English	Ordinary Farsi	Total number of words
8	23	5	7	0	0	43

In figure 2, Farsi mathematics register appeared not to have a verbal application when there was no visual (written mode) presented in Farsi. In figure 3, the combination of Farsi number words and mathematical operations which were said in Farsi constituted thirty words out of the total forty-three words and appears to exist a correlation between the written mode and the spoken form. O'Halloran (2009) speaks of how mathematical symbolism, language and visual images can be combined together in a process of meaning making. Different numerals such as Farsi or English numerals have a visual modality. A mode that is "socially shaped and culturally given resources for meaning making" (Kress 2009, 54). Heritage bilingual learners with a Persian background have access to two modes, that is, two different mathematical symbolic notations that are available as semiotic tools (O'Halloran 2005).

Conclusion

What I have shown in this study is the extent to which a written mathematics text constructed using a natural language, influences the spoken counterpart in that specific language. For example, in figure 2, when the instructions were given through the medium of English only with English numerals, it had a very strong effect on the spoken part. Moreover, when the instructions were given in Farsi with Farsi numerals, there appeared an increased frequency in Farsi mathematics register and in Farsi number words with fewer English mathematics register.

Based on the findings of this study I am interesting to investigate further research to know whether other languages with different orthography systems (such as Chinese numerals) influence their correspondent verbal counterpart (e.g. in a bilingual Chinese/English mathematics lesson). Moreover, to what extent the concept of 'conformity' among bilingual learners in a bilingual lesson can influences the bilingual talk.

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