Language barriers in mathematics education: Some findings from Fiji

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Introduction

Mathematics is strongly connected with language, and to succeed in mathematics a student must be able to competently understand and use mathematical language (Kazima, 2006; Kotsopoulos, 2007; Xi & Yeping, 2008). This may present some unique challenges for students as they must simultaneously learn ordinary English and mathematical English, and be able to differentiate between the types of English (Abedi & Lord, 2001; Moschkovich, 2005; Winsor, 2007). To understand mathematics in an English medium classroom, English language learners may undergo more processing than native English speakers (Clarkson, 2007; Meaney, 2006). Furthermore, to be able to perform competently, students must understand the highly technical language used specifically in mathematics (Brown, Cady & Taylor, 2005). This language is not used in everyday English, and therefore is less likely to be familiar or understood by English language learners. The technical language and mathematics vocabulary is not only essential for students to be able to understand and access the mathematics they are learning now, but has a significant influence on their future mathematical development (Hoffert, 2009; Xi & Yeping, 2008).

The paper has three sections. The first section draws on mathematics education research to discuss the challenges faced by English Language Learners. The second section reports on data gathered from a larger qualitative study that investigated high school students' statistical ideas. I will draw on examples from my work from Fiji to explain the impact of language issues in statistics education. The final section considers the issues arising out of the discussions and offers suggestions for meeting these challenges.

Problems faced by English Language Learners in mathematics

There is a growing demand on students' linguistic skills in mathematics lessons. Pupils at all levels are not only expected to listen, talk and read, but also to write about their work in mathematical language. However, reasoning at complex cognitive levels through mathematical discourse is not something many students are able to achieve easily due to interference from everyday language and the mathematical register.

Word meanings: Ordinary English versus mathematical English

Students come to mathematics with an existing vocabulary, however, some words they are familiar with may be used in mathematics to express different or very specific concepts, for example, 'expand.' Confusion can develop due to the mismatch between a student's existing understanding of the word and the context in which it is used in mathematics.

In addition, mathematics contains a number of new words, outside of those used in everyday English (Rangecroft, 2002). This requires that students learn these words and their meanings to be able to experience success in mathematics.

Furthermore, statistics has a different set of words compared to regular mathematics. As well as words that are used in everyday English, and mathematical English, there are also words that are specific to statistics (Lesser &Winsor, 2009; Kaplan, Fisher & Rogness, 2009). Finally, there is the added confusion with words that differ in ordinary mathematics and statistics, or ordinary English and statistics (Rangecroft, 2002).

Language syntax and translation
English is a complex language with a complex syntax (Kazima, 2006; Padula, Lam & Schmidtke, 2001). Sometimes, the structure of natural English is at odds with the conventions of mathematical language structures (Kaplan et al., 2009).

Register
In the mathematics classroom, multiple registers are used (Pimm, 1987). For students to succeed in a mathematics classroom, they need to not only be familiar with and competent in their ordinary English register, so they can communicate with their classmates, but must also have fluency in what can be termed multiple mathematical registers (Boero et al, 2008; Kazima, 2006). The mastery of the mathematical registers, and the strong ability to switch between them, requires strong linguistic and metalinguistic skills. These skills are necessary for students to be able to cope with more advanced mathematics (Boero et al., 2008).

For a student from an English speaking background, mathematical registers can pose a significant challenge, as a new form of language must be learned and mastered (Moschkovich, 2005). Not only must an English language learner try to learn in English whilst concurrently learning to speak English, they must also be working within the English mathematical registers without yet having mastery of ordinary English. They must be able to understand the mathematical register, translate it into ordinary English, then translate that into their own language, before translating it into one of the mathematical registers used in their home language. Therefore, even if an English language learner is competent in using the ordinary English register, the use of the mathematical register provides extra difficulties for English language learners.

My study
The research was conducted in Fiji, my home country. Overall, it was designed to investigate what ideas from five students have about statistics and probability, and how they construct these ideas.

Background
Fiji is a diverse country in terms of language and culture. Majority of the population does not speak English as their first language. English is the official medium of instruction for teaching and learning. The mother tongue is used for an initial period of instruction (usually about 3 years) to facilitate the use of English as a medium of instruction for the remainder of the students' education.

Sample
The study took place in a co-educational private secondary school in a rural town. The school roll was about 400, the majority being Indians. It was an average high school, and the staff were interested in being involved in the research project.

The sample consisted of a class of 29 students aged 14 to 16 years of which 19 were girls and 10 were boys. Fourteen students participated in the individual interviews. The sample was selected in consultation with the class teacher.

Tasks

The instrument consisted of probability and statistics tasks, each with a series of questions. Due to space limitations, data from two probability tasks are reported here. In contrast to traditional pedagogic setups, which are limited to closed questions, in all tasks students were provided opportunities to either explain their thinking or express their opinions. The two tasks are described below**.**

An advertisement regarding the sex of a baby (Item 1) explored students' understanding of the concept "equally likely" in an everyday context.

Item 1: Advertisement involving sex of a baby

> Expecting a baby? Wondering whether to buy pink or blue?
> I can GUARANTEE to predict the sex of your baby correctly.
> Just send $20 and a sample of your recent handwriting.
> Money-back guarantee if wrong!
> Write to….....
> What is your opinion about this advertisement?

The comparison of probabilities problem, Item 2 was used to explore students' conceptions of "proportional reasoning" which is crucial to a conceptual understanding of probability.

Item 2: Black and white marble problem

> Meena and Ronit have some marbles. Meena is 10 years old. In her box, there are 10 white marbles and 20 black ones. Ronit is only 8 years old. In her box there are 20 white marbles and 60 black ones. They play a game. The winner is the child who pulls out a white marble first. If both take out a white marble at the same time then no one is the winner and the game has to go on. Ronit claims that Meena has a greater chance of pulling out a white marble because she is older, and cleverer.
> What is your opinion about this?

Interviews

I interviewed each student individually in a room away from the rest of the class. The interviews were tape recorded for analysis. Each interview lasted about 40 to 50 minutes. Paper, pencil and a calculator were provided for the student if he or she needed it.

Results and discussion

The interview results show that there were a number of cases where students tried to construct meanings for statistical terms by relating to their everyday meanings. Extracts from typical individual interviews are used for illustrative purposes.

None of the students was considered statistical on Item 1. This could be due to the context of the task or language difficulties. For example, one student thought that this problem has really to do with a doctor charging a $20 consulting fee to inform the parents of the sex of their unborn baby. Even when challenged about how the people placing the advertisement could make money, the student could not see that roughly half the babies born would be girls and half would be boys. The powerful nature of their everyday reading strategies of skimming and using the context or knowledge of the world to support comprehension are reflected in the following interview:

S The doctor may be charging $20.
I: This could be any person charging $20 for predicting the sex of the baby. What is your opinion about this advertisement?
S: No.
I: What do you mean by "No"?
S: Because it's a bad thing. They change the sex.
I: They are not changing the sex, they are just predicting the sex of the baby by looking at the hand writing. So what's your opinion about it now?
S: That when anything goes wrong then they must know the handwriting of the person.

Three students said that the advertisement was placed just to earn money. When asked to explain their thinking, students talked about businesses putting advertisements to sell their products. There was no evidence of students integrating theoretical and experimental views of probability. The students had an idea that the problem was to do with determining the sex of the baby but then seemed to associate it with notions of childbirth difficulties. It appears that for these English language learners working in different registers posed challenges as a new form of language must be learned and mastered.

The findings resonate with the conclusions of (Boero, Douek & Ferrari, 2008; Kazima, 2006). For the students to succeed with the problem, they needed to not only be familiar with both ordinary English and mathematical registers, they needed strong ability to switch between them in order to cope with different interpretations of probability. Additionally, not having the necessary technical, mathematical vocabulary may have hindered student' mathematical communication.

Rather than attending to proportionality information given on the marble task, two students based their reasoning on previous sports experience.

S: Eh ... So if you play a game it should be equally in number.
I: What do you mean by equally?
S: Like soccer; if you are playing there should be 11 players side. Then you will be able to have a win, eh. So here it is like marbles. It is 10 white and 20 black marbles. So the game should be equally.

It is clear that this student, instead of performing adequate proportional calculations, used his prior experience to deal with the task.

A few students missed the point of the question (Item 2) by focusing on whether the game was fair. This is reflected in the comment made by a student:

> This is not a fair game; for this the game should be played by same aged people and there should be equal number of marbles in the box.

One student explained why it was fair that Ronit, the younger child, had more marbles.

> At my home, I got three brothers, so when my father gets two apples, then he gives one whole apple to my smaller brother and us two brothers, we get half each.

"Fair" in the statistical context means whether each player has the same theoretical chance of winning a game (Watson, 2006). However, in everyday register, "fair" has different meanings, for example, unbiased, in accordance with the rules of equity. The response indicates that when students are engaged in mathematical discourse they use words and terms from the spoken language while remaining aware that they have to relate to their mathematical meaning. Since "fair" has a different meaning in everyday language, the first denotation that comes to mind is the everyday use of the term.

The findings indicate that in some cases the meaning intended by myself on the interview tasks was not that constructed by the students. As a result, students constructed responses based on these unintended interpretations. Ordinary expectations of the way words are put together in English led students to assume that the phrase *at the same time* in the question will mean some action. For instance, one student interpreted the problem involving Ronit and Meena as a game involving competition and a winner.

> I: Now, can you tell what chance does Meena have of getting a white marble?
> S: Eh ... Meena should be fast, so hands will be fast, so she would be able to take it out first; and Ronit is 2 years younger than her, so he will be not really fast.

The above findings are consistent with the findings of Padula et al. (2001). The authors stated that reading mathematical texts provides the learner with an extra challenge over reading English because they have to simultaneously comprehend and process in both the language of English and the language of mathematics.

Conclusions

Some students in this sample clearly had difficulty explaining explicitly about their thinking. Answers given to the problems may not represent the students' thoughts because language-related questions might have confused them. Despite these limitations, the findings of the study have several implications for teachers and research.

Teachers need to be aware of the issues surrounding teaching mathematics to English Language Learners, and plan accordingly. Not being aware of these issues can have detrimental consequences for students. What is of greater concern, is that while primary teachers may be aware that language development is an essential component of

mathematics learning and know how to promote it, secondary mathematics teachers, due to the lack of training in language teaching techniques, may not know what to do to help students with low levels of English language competence (Edwards, 2012). This has implications for teacher educators.

It appears that learning about probability constructs is a complex process and requires more emphasis and explicit planning, teaching and assessment. Furthermore, teachers need to consider integrating both academic language and domain knowledge in the classroom. Such integration will enable students to construct meanings from data and build the foundation for an understanding of these ideas.

The participants in my study were a fairly small non-random sample from one school. Thus, the findings, in particular the number of students who thought about probability in a particular way may or may not generalize to the population of secondary school students as a whole in Fiji. There is a need for more research with larger, more random samples with different backgrounds to determine how common these ways of thinking are in the general population.

As mentioned earlier, the results reported in this paper were part of a larger study, which focused on a number of areas of statistics. Since there had been virtually no research focused on probability outside western countries, it was not clear when this study was conducted that the questions discussed in this paper would be as rich and interesting as they were. Now that the language aspects described in this paper have been identified as possible areas of concern, there is a need for more qualitative research focused on a deeper understanding of students' thinking about probability concepts.

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