One Teacher's Dilemma in Mediating Translation From Written to Symbolic Form in a Multilingual Algebra Classroom

Anthony A. Essien

University of the Witwatersrand, Johannesburg, South Africa

This study investigated how a teacher in a multilingual classroom attempted to support learners who are struggling to translate written/verbal mathematics into a symbolic form. Thirty-six Grade ten learners in one multilingual classroom in South Africa were given a written test involving one algebraic question and then a discussion on the solution ensued. The results of the written test by learners, analysis of class discussion and the interview with the teacher all revealed the complexity of discerning or situating learners' difficulty due to either language limitation or lack of understanding of the mathematics concept or both.

Keywords: multilingual mathematics classroom, mathematics symbolism, algebraic equation, equivalence

Introduction

The debate surrounding the relationships that exist between language and mathematics and between language and mathematics learning is not new in research on the teaching and learning of mathematics. Most researchers and scholars are, however, in agreement that proficiency in the LoLT (language of teaching and learning) and to some extent, in the home language of learners (where it is different from the LoLT) plays an important role in the mathematics acquisition of learners (Adler, 2001; Barwell, Barton, & Setati, 2007; Cummins, 1979a; Essien, 2010; Setati, 2008). In South Africa, even though the constitution and the language in education policy give provision for learners to study in any of the 11 official languages of their choice (DoE (Department of Education), 1997; 2002), research has shown that economic, political and ideological factors compel learners to prefer to learn mathematics in English (Setati, 2008). Underachievement in mathematics in (some) multilingual classrooms has generally be attributed to the language limitations experienced by learners. Little attention has been paid to the interrelationship between understanding the mathematics concept and linguistic limitation with regards to the translation from written to symbolic form in multilingual classrooms. Yet, this is what teachers in multilingual classrooms have to deal with each day, as they teach mathematics problems involving the translation from written/verbal to symbolic forms. It is the author's contention that not only is the language of the mathematics at playing in such mathematics problems, but also the mathematics in the language is of essence. Understanding the mathematics in the language entails that one is able to correctly interpret the demands of the questions and appropriately engage with it. Such an understanding requires a deep rooted understanding of the concepts and the linguistic nuances within the mathematics problem.

Given the complexity of language structures and the confusion that might arise from the translation from verbal/written mathematics to symbolic form, the mathematics in the language is not without its difficulties.

Anthony A. Essien, lecturer, Marang Wits Centre for Maths and Science Education, University of the Witwatersrand.

This study explored this intricate relationship between conceptual understanding and linguistic limitation, and the difficulty in translating written (or verbal) mathematics into a symbolic form in algebra. It focused specifically on how a teacher mediates this difficulty. The key question the study seeks to address is: In a multilingual classroom, how can a teacher ascertain whether learners' difficulties in algebra are due to language difficulties but not conceptual limitation of the learners? A teacher who understands where the difficulty of the learners stems from with regards to the above would be better able to assist learners.

Mathematical Symbolism

In the relationship between language and mathematics, language serves as a medium through which mathematical ideas are expressed and shared (Brown, 1997; Setati, 2002). As Rotman (1993; as cited in Ernest, 1994, p. 38) argued that mathematics is an activity which uses "written inscription and language to create record and justify its knowledge". Language, thus, plays an important role in the genesis, acquisition, communication, formulation and justification of mathematical knowledge and knowledge in general (Ernest, 1994; Lerman, 2001). Pirie (1998) and Driscoll (1983) contended that mathematics symbolism is the mathematics itself and language serves to interpret the mathematics symbol. They both argued that even though brevity is strength in symbolism, this symbolism in itself can be the root cause of misunderstanding as many research have revealed. To deal with difficulties associated with mathematics symbolism, Lesh, Post, and Behr (1987, p. 648) contended that there are five steps involved in translating a problem (to a symbolic form): (1) simplifying the original situation by ignoring irrelevant characteristics in order to focus on more relevant factors; (2) establishing a mapping between the original situation and the "model"; (3) investigating the properties of the model in order to generate predictions about the original situation; (4) translating (or mapping) the predictions back into the original situation; and (5) checking to see whether the translated prediction is useful. In the author's view, what is back grounded in the above steps is recognition of the complex process of learning mathematics in an additional language. Learners who come from homes where the LoLT is the only language spoken are to some extent familiar with the linguistic structures they encounter in the mathematics classroom (Barwell, 2002; Cuevas, 1984), even though they still have to deal with the mathematics language (Pimm, 1987). Researches (Adler, 2001; Barwell, 1998; Barwell et al., 2007; Clarkson, 1991; Gorgorio & Planas, 2001; Halia, 2004; Setati, 2002) have shown that it is not the case with learners whose home language is not the language of teaching and learning. These learners need to deal not only with learning mathematical concepts, but also the language in which these concepts are embedded (Barwell et al., 2007). In multilingual classrooms of learners whose home language is not the LoLT and who are not yet proficient in the LoLT, teachers are faced with the triple challenge of striking a balance among attention to mathematics, attention to English (LoLT) and attention to mathematical language (Barwell, 2009).

Research Method

Research Design

In order to address the critical questions that this research sought to explore, a qualitative case study approach was adopted. Case studies involve detailed contextual analysis of a limited number of events and their relationships that can strengthen what has already been known through previous research (O'Leary, 2004; Soy, 1997; Van der Merwe, 1996). The author's choice of a case study was motivated by its ability as a research method to bring new variables or understanding to the fore.

Sample

Thirty-six Grade ten learners and their teacher were involved in the research. Twenty-five of the learners have Zulu, Xhosa or Setswana as their first language. Their conversational English was, however, fairly fluent. Eleven of the learners have English as their first language. The teacher, Miss Bonga, is fluent in Zulu, Sesotho and English. Miss Bonga's class was chosen for data collection for two reasons: First, Miss Bonga had undertaken a course on teaching and learning in multilingual classrooms earlier in the year and was, thus, conscious of the challenges involved in teaching in such a context; Second, there was a high level of teacher-learner and learner-learner interaction in her class compared to other classes in the school. Furthermore, Miss Bonga believed that the greater part of the difficulty experienced by learners is due to language difficulties. This belief is not uncommon amongst teachers in multilingual class in South Africa.

Data Collection

Data were collected through observation involving the implementation of the research instrument below.

There are eight times as many boys as there are girls in a school which represents learners in the school in an algebraic equation.

There were several other mathematics problems posed by the teacher during the period of observation by the researcher. The above particular question was chosen because it deals directly with translating from written to symbolic form in mathematics. It was also chosen for analysis because it is a word problem requiring learners' correct interpretation and understanding of the language to adequately engage with it. The question also requires a good grasp of the equal sign as a relational symbol indicating quantitative sameness, that is, a good grasp of the concept of equivalence (Essien & Setati, 2006). Learners were given ten minutes to write down the algebraic equation. Then, they were asked to discuss their solutions in groups of four. This was followed by a whole class discussion for 20 minutes where the teacher tried to probe learners' thinking and requested justification of solution processes. At the end of the class, the teacher was also interviewed.

Analysis and Findings

All the learners represented the number of boys with a variable and the number of girls with another variable. For the sake of this paper, the author will represent the number of boys with b and the number of girls with g. Table 1 shows how learners engaged with the question in their individual test.

Table 1

Learners' Solution to the Maths Problem

Solutions given by learners	Number of learners with this solution
$8b + g$	11
$8b = g$	24
$8g = b$ or $b = 8g$	1

As shown in Table 1, more than half of the learners interpreted the question literally, as it is written in English. Thirty-one percentages of them interpreted the question as asking how many learners were in the school. In the class discussion that ensued, the teacher tried to get learners to justify their solutions.

Teacher: Mabel, what was your answer to the question?

Mabel: $8b + g$, ma'am.

Teacher: How did you get that?

Mabel: I said, if *b* equals boys and *g* equals girls, then there would be $8b + g$ learners in the school.

Teacher:Read the question again. What does the question require of you?

Mabel: There are eight times as many boys… (Read the question).

Teacher: So what do you think? What is the question asking of you?

Mabel: It is asking that… that I… I…

Teacher: Can someone else help her? Yes, Tsiki.

Tsiki: It is asking that we represent the above statement as an algebraic equation.

Teacher: Can you say it in your own words?

Tsiki: It wants us to write an equation for eight times as many boys as there are girls in a school.

Teacher: And what do you think?

Tsiki: I think it would be that eight times boys equal girls. So, if *b* stands for boys and *g* for girls, it would be $8b = g$.

Teacher: What do others think? Temi, what do you think?

Temi: Eh … eh… I…

Teacher: What did you write?

Temi: I… I… I… (she was one of those who wrote $8b = g$).

Adler (2001) advocated that in a participatory-enquiry approach, such as the one used by Bonga, a high demand is placed on learners' communicative competence. The learners in Bonga's class have been tackling non-routine problems in diverse areas of the curriculum. As a part of their participation in such a learning environment, learners are usually urged to express/justify their thinking and critically examine one another's solution as evident in the above excerpt. Bonga has noticed that some learners were usually quiet in class and had attributed their lack of participation to their English language competence level or timidity. She made it a point of duty to call on these learners to speak in class. On watching the video-tape of her lesson with Bonga, she explained that:

> Even though I was not surprised that learners wrote $8b = g$, I was struck that only one person was able to write the correct equation, and he is a Zulu first language speaker. I then thought to myself that they may be something more than language at stake here. But before trying to figure out what actually could be the problem, I tried to get learners to understand the key words in the question to see if that would help them understand the question better.

After noticing that learners did not understand the question well, Bonga decided that dissecting the question would help:

> Teacher: I still need someone to explain to me his/her answer. Yes, Dave.
>
> Dave: The equation, would it not be $8b = g$? It is there in the question and it's easy to see: eight times the number of boys equals girls.
>
> Teacher: Let us look at the key word or phrase in the question. What is it or what are they? Think. Yes, Luandile.
>
> Luandile: Is not it "as many"?

Teacher: What do others think?

Mabel: I think it is "eight times as many boys as there are girls".

Teacher: Let's take it from there:What does that mean? Eight times as many boys as they are girls.

Dave: Eight times the number of boys equals girls.

Teacher: Which is greater? Number of boys or number of girls.

Learners: (Chorus) boys.

Teacher: How? Who can give me a reason?

Hlengiwe: Eight times as many boys as there are girls. There are more boys.

Even the attempt to analyse the key words or phrases did not help much in the understanding of the question. As Driscoll (1983) argued, the difficulties that learners experience in symbolic formulation of the mathematical written/verbal problem is not due solely to the confusion about words or vocabularies in the question. During the interview, the author asked the teacher why she thought that the English first language speakers did not answer the question correctly:

Bonga: You know, any interpretative activity, such as the question above requires a sort of understanding of language in question. There is understanding of the language; there is also understanding of the mathematics.

Researcher: In the question, would it be possible to engage with it if you do not understand the language? And would it be possible to engage with it if you do not understand the maths?

Bonga: I believe that the two are much related to each other. Learners need to understand both the language and the maths to correctly solve the problem. They need the language to interpret the words into algebraic equation, and the maths to check if their answers are correct. You see, that was why when I noticed that grasping the key words and phrase in the question did not work well, I switch to numerical representations hoping this would help.

Teacher: Consider the question again, assuming there is only one girl in the class, how many boys would there be?

Thandi: Eight boys.

Teacher: if there are two girls, how many boys would we have?

Thandi: Sixteen boys.

Teacher: Now, if there are g girls in the class, how many boys are there? Yes, Koko.

Koko: $8g$.

Teacher: Now, if b represents number of boys and g the number of girls, write and equation relating number of boys and number of girls in the class.

Even after this tactics of using numbers, the learners still did not fully grasp the explanation. The confusion inherent in translating the question above to symbolic form as Clement et al. (as cited in Driscoll, 1983) pointed out, is due to the direct translation or mapping of words in English into algebraic symbol. Bonga seemed to believe that learners' confusions of believing that "$8b$" represented the larger group and "g" indicated the smaller group (Driscoll, 1983) was due solely to language difficulty. As Pirie (1998) pointed out, mathematical symbolism in a way is the mathematics and is interpreted through the medium of oral/written language; but within the mathematics register, verbal/written expressions do not always match symbolic forms.

From the above excerpts, it can be observed that learners used the word "times" in the expression "as many times as" to mean "times" as in a time "*b*" equal "*ab*".

Discussion

Any teaching or learning of mathematics involves activities of reading, writing, listening and discussing (Pimm, 1991). Language serves as a medium through which these mathematical activities are made possible. By asserting that mathematical activities are essentially interpretative in nature, we give primacy to the interpretative ability of learners and by consequence, their linguistic ability in the language in question. But to what extent can it be deduced that the difficulties experienced by learner are primarily due to the language competency level? In other words, when can we know that the difficulty is due to the English but not to the mathematics itself—not the difficulty of translating from written to a symbolic form. Bonga struggled with this dilemma. She could not understand why none of the learners with English as first language could correctly engage with the question. She then surmised that the difficulty in the concept of equation could be at stake here. Still not convinced of her conjecture, she then decided to use numerical values to gradually help her learners to understand the question. Using numerical values to facilitate mathematical algebraic thinking in learners can help mediate language and conceptual problems. But is this tactic always successful? Can letters in all algebraic word problems be substituted for numbers? Are there cases where the use of numbers can aggravate rather than alleviate difficulties in the translation from written mathematics to symbolic form? Could code-switching have helped in easing the language problem? If code switching had been used, would learners have still recognized that $8b = g$ was wrong? These are the questions that should plague the minds of any teacher desirous of mediating the translation from written/verbal mathematics to symbolic form. The present study (even though small scale) is a clear indication that language problems are inherent in mathematical problems for both first language and additional language learners.

Conclusions

Language is a key component in the construction of mathematical knowledge in the classroom (Gorgorio & Planas, 2001). In algebra, as in some other aspects of mathematics, this relationship is a very complicated one and can pose problems to learners in the interpretation of questions. At times, understanding the mathematics in the language is not a straightforward matter, and the teacher's role of mediation, when it comes to symbolic formulation from written expression (where it is not clear that what is at stake is the understanding of the English or the understanding of the math) in a multilingual classroom, is a daisy one. This paper has posed more questions than proffer solutions to Bonga's dilemma. It is hoped that these questions would induce further research into the intertwinement of language and mathematics in the teaching of the concept of equivalence when learners are first introduced to algebra at Grade eight level.

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