Concept Literacy in Mathematics and Science: experiences with the development and use of a multilingual resource book in Xhosa, Zulu, English and Afrikaans in South Africa
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Introduction
It goes without saying that the understanding of key concepts in mathematics and science is fundamental to the teaching and learning of these disciplines. Research confirms that one of the key dimensions to understanding concepts is language. The intimate relationship between language and the understanding of concepts is well documented. For example, the poor performance of South African learners in the 1995 and 1999 TIMSS is largely ascribed to the problem that learners and teachers have in studying and teaching through English as a second or even third language. To address this problem a multilingual learning and teaching resource and support book (Grade 9 – 10 levels) was developed at the Centre for Applied Language and Literacy Studies and Services in Africa (CALLSSA) at the University of Cape Town in collaboration with Rhodes University and the University of Kwa-Zulu Natal. The book provides detailed meanings and explanations for key mathematics and science concepts in Zulu, Xhosa, Afrikaans and English. It is argued that when learners and teachers have access to these concepts in their own languages, they can transfer such understanding to their dealing with English as the language of learning and teaching (LoLT). The book was validated through a collaborative process involving the three universities. The validation process was enhanced by a research process of trialing and evaluating the book in classroom practice. This inter alia included an investigation of:
- the accuracy of the concept explanations in the four languages used;
- the appropriateness of the translations;
- the general effectiveness of the book as a learning and teaching resource.
The research involved the participation of Grade 10 teachers in the Western Cape, Eastern Cape and Kwa Zulu Natal of South Africa. This paper aims to share some of the experiences encountered in the development of this book by briefly describing the development process and the content of the resource book, and also highlighting some of the research issues that were encountered with special reference to code-switching practices as a central pedagogical strategy in many South African classrooms.
Copies of the book will be distributed at the presentation for discussion.

A concept literacy resource book
The problem of language proficiency as an obstacle to learning mathematics and science is well documented (Adler 2001, Howie 2002, Setati 2005). Young, van der Vlugt and Qanya (2004) suggest that this problem can be addressed at two inter-related levels:
- concept understanding and use, and
- language/discourse contexts and forms in which these concepts are embedded.
The notion of concept literacy that framed the development of the multilingual resource book can be described as “understanding, through reading, writing and appropriate use, basic learning-area specific terms and concepts in their language contexts” (Young at al, 2004). Kilpatrick, Swafford and Findell (2001), describe conceptual understanding as a critical component of mathematical proficiency that is necessary for anyone to learn mathematics successfully. Conceptual understanding implies an understanding of knowledge that not only revolves around isolated facts but includes an understanding of the different contexts that frame and inform these facts. Kilpatrick et al (2001) suggest that “students with conceptual understanding …have organized their knowledge into a coherent whole, which enables them to learn new ideas by connecting those ideas to what they already know”.

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The idea of a concept is controversial and difficult to define. It ranges from a personal idea or construct to a statement that is universal and generic. The definition that underpins the resource book suggests that a concept is a “mental picture which has a standard and universally accepted meaning” (Young et al., 2004). Similarly the notion of literacy is difficult to pin down as it no longer simply refers to the ability to read and write. Young et al. (2004) argue that literacy implies a capacity to recognize, reproduce and manipulate the conventions of text, spoken and written, shared by a given community. Concept literacy therefore emphasises the interaction between context and content. It is a process that is dynamic and that changes over time as the concept is internalized and understood. From a Vygotskian and constructivist perspective this implies that concept literacy involves the modification of prior conceptions and experience. Fundamental to this process is of course language proficiency. Young et al. (2004) correctly argue that it is therefore likely that modifying one’s prior knowledge if one is learning in an additional language (a language other than the first language) can be problematic, particularly if one is not proficient in that additional language.

For most South African teachers and students of mathematics and science the LoLT in these disciplines is English – an additional language that for many is difficult to understand and use. To address these difficulties CALLSSA embarked on writing a learning and teaching resource and support book for Mathematics and Science. This book provides detailed meanings and explanations for key concepts in Xhosa, Zulu, Afrikaans and English within the framework of the Revised National Curriculum Statement (RNCS) at a Grade 9 – 10 level. It lists about 60 key RNCS mathematics and science concepts that are grouped under the themes time, space and number for mathematics and energy, matter, earth and life for science. Very importantly, attention is also given to the everyday English meanings of these specific concepts. As Young et al. (2005) note, the words and language forms of mathematics and science often differ markedly from those of everyday use of the same words. For example, concepts like power, force, revolution, work and pressure have very different everyday meanings to their specialized meanings in mathematics and sciences.

The development of the book was a collaborative process with teachers of mathematics and science in the Western Cape, Eastern Cape and Kwa-Zulu Natal, and validated by expertise in mathematics and science education, Xhosa, Zulu and Afrikaans from across South Africa. In its introduction the book acknowledges some of the dilemmas that were faced in translation and explanations of concepts:

We are very aware of questions about which Xhosa or Zulu words or terms for these concepts are ‘correct’, standardized forms. We have, wherever possible, tried to ensure that our uses of both Xhosa and Zulu are correct. Until these two languages, and other African languages, are fully standardized, our text must serve as an interim attempt to offer translation equivalents in Xhosa and Zulu for English concepts dealt with in this book. We think it is better to present work close to the ideal as a starting point rather than to have nothing available!

Teachers from across the three provinces participated in the development phases of the book by trialing sections of the initial manuscript and providing feedback on their experiences. Lessons were videotaped and deconstructed with the participating teachers. Issues such as inaccuracies in translations and the use of inappropriate and inaccessible diagrams were identified and noted. These were then incorporated in the final version of the book. The book was marketed in all the provincial education departments of South Africa and those provinces where Xhosa and Zulu are particularly prevalent, have ordered copies for their teachers.

**Code switching and some tentative research results**

South Africa is a multicultural and multilingual country with a diversity of 11 official languages. Although the Language-in-Education Policy insists that the LoLT in the first four years of schooling is mother tongue, the use of code-switching is common practice in most schools where
the home language of teachers and learners is not English. In South Africa these are mostly schools that, in the apartheid years, were classified as black- or township schools. Code-switching is the practice where “an individual (more or less deliberately) alternates between two or more languages” (Baker, 1993:76 – 77). As Setati (2005:91) notices, code-switching “can be between languages, registers and discourses”. In the South African classroom, code-switching would typically involve an indigenous language and English. Despite the fact that the medium of instruction changes to English after Grade 4, the practice of code-switching is often sustained for the entire duration of schooling. It is argued that code-switching can be a powerful and effective pedagogical tool to overcome language barriers to teaching and learning. As Setati and Adler (2001) noticed, many teachers in South Africa have a dual task of teaching both mathematics and English at the same time. It goes without saying that by the same token, learners also have to cope with the language of mathematics and the language in which it is taught – and this in many instances is a second or even third language. Recent preliminary pilot research by Tokwe and Schafer (2009) explored how the Concept Literacy book in question impacted particularly on the code switching practices of selected Xhosa speaking Grade 10 mathematics teachers. Four teachers (A, B, Y and Z) were involved in the pilot study. Their code switching practices were observed and documented over a number of lessons before the Concept Literacy book was introduced to two of the teachers, Y and Z. After using the book over a period of a two terms their code switching practices were once again observed and documented.

The figures below illustrate the code switching practices of teachers A and B.

It is interesting to note that when giving instructions, both teachers preferred to use the vernacular. This trend however changed when the teachers started to explain and illustrate mathematical concepts and terms. The use of English became more prominent and the practice of code-switching increased. This is illustrated in the following conversation:

Consider the situation whereby siza kuthatha ii triangles zethu ezimbini sizibeke on top of one another.

What I’m trying to say is this [drawing 2 triangles adjacent to each other]. Translation: Consider the situation whereby we will be taking our two triangles and put them on top of one another. What I’m trying to say is this [drawing 2 triangles adjacent to each other]

If you say now all angles of a triangle are equal, ingaba i angle inye kuzo err ndicinga ukuba.......... 

Ingaba inye iza kuba how many? (Teacher and learners respond simultaneously.) “Ngu 60 degrees.”

Translation: If you say now all angles of a triangle are equal, is it that one of the angles err. I think that.......... How many will one of them? (Teacher and learners respond simultaneously.) “It is 60 degrees.”
“In other words, ukuba siza kuthi le yi parallelogram, so that means eli cala lingapha liza kuba parallelewaka cala lingaphaya and eli lona libe parallelewaka lwe multiphaya.” Translation: “In other words, if we say that this a parallelogram, so that means this side here will be parallel to that side on the other side and this one will be parallel to the one on the other side.

The above scenario is however not surprising if one considers the lack of a mathematical register in Xhosa and the dearth of mathematical resources and texts in that language. There are many constraints in mother-tongue education, as Probyn (2002:10) states “…there are [numerous] linguistic and economic constraints on mother-tongue education: the fact that indigenous languages have not been used for academic purposes means that the necessary terminology and textbook resources have not been developed”.

Teacher Y and teacher Z displayed very similar practices. When going to press the data was not yet analysed and processed sufficiently to illustrate these practices graphically.

The figures below illustrate the code switching practices of teachers Y and Z after the Concept Literacy Resource book had been used over a period of time.

It is interesting to observe that after the Concept Literacy Resource book intervention, the use of Xhosa increased markedly for the following categories of communication: asking questions, expressing self and explaining. Notwithstanding the small sample and the tentative nature of the pilot, this suggests that the Concept Literacy Resource book had an impact on the code switching practices of the participating teachers. Their use of their first language increased and they appeared more confident in using Xhosa in mediating mathematical concepts.

In general, the Concept Literacy Resource Book was well received and initial classroom visitations revealed the following:

**Deep Xhosa vs everyday Xhosa.** A number of the teachers felt that the Xhosa that was used in the resource book was at times difficult to understand. They felt that the translations were dominated by ‘deep’ Xhosa – sometimes also referred to as rural, old, traditional, formal Xhosa as opposed to ‘township’ Xhosa – also referred to as everyday, modern Xhosa. According to the teachers, many of the learners expressed similar sentiments.

**Inconsistent use of Xhosa.** In some instances it was felt that the translation used in the text was not consistent with some of the dictionaries that the teachers had access to (Schäfer, 2005).

**Assistance in conceptualization.** A number of teachers said that the Xhosa text assisted in their own conceptualization of a particular concept. This also applied to many of the learners who were provided with photocopies of the text in various lessons (Schäfer, 2005).

**More comprehensive translation.** There was widespread consensus that the entire book needed to be translated into Xhosa and not just the key concepts (Schäfer, 2005).
Texts in mother tongue. Many of the teachers felt that they themselves were not aware of the existence of some of the Xhosa terminology and were surprised when they encountered some of the terms in their own language. There was consensus that a standardized Xhosa mathematical register needed to be developed as soon as possible. There was a strong commitment from the teachers to the preservation of Xhosa and many felt that it was important to teach through the medium of Xhosa. It was however also recognized that in an era of globalisation and market driven economies, the dominance and power of English cannot be ignored (Schäfer, 2005).

Resistance to Xhosa. There was resistance to the use of Xhosa by some learners. They felt that English was the international and dominant language and hence they needed to learn mathematics and science in that language. Incidentally, numerous teachers commented that a similar sentiment existed amongst some parents, who felt that teaching should be done through the medium of English and not through the mother tongue (Schäfer, 2005).

Support of textbooks and other learning areas. The resource book was used to support the textbook in lesson preparation and implementation. Some teachers photocopied pages out of the book to hand to the class (Schäfer, 2005).

Conclusion
Our research into the use of the Concept Literacy Resource book shows that a multilingual text of this nature is long overdue and could play an important role in enhancing the role of indigenous language in the teaching and learning of mathematics in South Africa. The development of a mathematics and science register in all indigenous languages is fundamental to the realization of the vision that asserts that each child should have the choice of his/her language of instruction.

References