CHALLENGING THE "APARTHEIDS" OF KNOWLEDGE

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Joana Bezerra, Craig Paterson & Sharli Paphitis (Eds)

Chapter 5

Translanguaging online: A case study of a bilingual online mathematics programme for Grade 7 learners in Diepsloot, Johannesburg

Nathalia Lourenço

SCHOOL OF LANGUAGES,
RHODES UNIVERSITY

nvonwitt5@gmail.com

1. Introduction

South Africa has an education system that was crippled by apartheid and is still not adequately developed to meet the needs of the South African people. Despite recognising 11 official languages, a prevailing form of unequal access to education is the use of English as the dominant language of learning and teaching (LoLT), which is a second language (L2) for 90.4% of South Africa's population (Statistics South Africa, 2012). With English becoming the LoLT after only three years of schooling, learners who are not raised in an English-medium environment will not yet have developed adequate proficiency in English (Heugh in Howie *et al.*, 2006) making it difficult for them to have meaningful engagement with the curriculum context. These language deficiencies are then exacerbated as learners progress to higher grades where content becomes more abstract and complex. With this being a lived reality for so many South African learners, it is imperative that this inequality is addressed.

2. Motivation: Language in education in South Africa

South Africa's education system is often considered to be in crisis, and mathematics and literacy are two areas which are at the forefront of the problem. For example, in the 2014 Annual National Assessments (ANAs), learners scored on average 43% for mathematics in Grade 6, but only 11% for mathematics in Grade 9 (Department of Basic Education, 2014). At Grade 6 level, 35% of learners achieved more than 50% in the ANA, while only 3% of Grade 9s achieved more than 50% (Department of Basic Education, 2014). This suggests that learners increasingly struggle with mathematics as the content becomes more complex and abstract and as their deficiencies in their foundational understandings become increasingly apparent.

The South African Language in Education Policy (LiEP) alludes to fostering additive bilingualism, that is, the learning of a L2 while maintaining the first language (L1) (Heugh & Luckett in Probyn, 2009). Additive bilingualism tends to foster higher language proficiencies in both languages and validates the learners' identities, supporting learners' pride in their identities (De Mejía, 2002). However, the L1 is used as LoLT only until Grade 3, and from Grade 4 onwards English is used as the LoLT (Howie *et al.*, 2006). This shift occurs too early, creating a language learning environment of subtractive bilingualism, wherein the L2 is learned at the expense of the L1 and gradually replaces it (Heugh in Howie *et al.*, 2006). The result of this is that learners often do not become fully proficient in either language, and have their self-confidence and feelings of self-worth diminished (De Mejía, 2002). This insufficient language proficiency then also limits learners' access to what is taught in all of their L2 subjects, making learners struggle throughout school (Wababa, 2009).

Even though many teachers are apprehensive about the use of L1 in classes where the L2 is the target language, codeswitching still occurs in classrooms (Moore, 2002). Setati and Adler (2000) found that the teachers in their study experienced the "dilemma of codeswitching" (Adler in Setati & Adler, 2000:255). Teachers need to use the learners' L1 in order to ensure their understanding of a concept, or to encourage discussion of the concept; however, teachers also need to use as much English as possible so that learners can become familiar with and competent in mathematical English (Setati & Adler, 2000). This dilemma is extended to the teacher's encouragement and allowance for their learners to use codeswitching (Setati *et al.*, 2002). While codeswitching is in some cases beneficial, codeswitching paired with the premature introduction of English as LoLT often results in 'semilingual' learners who have an inadequate grasp of the

languages or the curriculum. While the use of codeswitching in the classroom is important both pedagogically and politically, it is also a complex matter (Setati & Adler, 2000). Although the LiEP encourages codeswitching in the classroom (Setati, 2002), very little guidance is given on how to do so, and there are no readily-available resources for teachers to guide their codeswitching. This project undertook to create a replicable codeswitching model which could be implemented in addition to existing policies, in this way attempting to solve a social or educational problem by combining new and existing practices.

3. Context

3.1 *Diepsloot, Johannesburg*

This research was undertaken in Diepsloot, a township in northern Johannesburg, South Africa. Diepsloot was planned and created by the apartheid government in the early 1990s (Bénil, 2002), and has grown rapidly, with an estimated current population of around 200 000 (Cross, 2014). The great majority of Diepsloot's population are black Africans (97%), and almost 20% of Diepsloot residents are foreign nationals (Mahajan, 2014). Many people live in or move to Diepsloot because of its proximity to work opportunities in relation to other townships (Mahajan, 2014). As a result of people moving to Diepsloot in search of economic opportunity, the mix of language and cultures is extremely diverse, making Diepsloot a reflection of the multilingual country in which it is situated. Many of the schools in Diepsloot teach in Sesotho, Sepedi, Setswana or isiZulu for the Foundation Phase (after which English becomes the LoLT), and these languages are offered as the home language. While very few school children speak English at home, they are exposed to written English on the posters, signs and flyers found in Diepsloot and, for those who have access, on the radio and television.

3.2 *OLICO Maths Education*

For this project I worked with OLICO Maths Education, a not-for profit non-governmental organisation that runs an after-school academic support programme in Diepsloot. OLICO Maths Education was created with the vision of living "in an inclusive, just and humane society without poverty" (OLICO Foundation NPC, 2015).

OLICO Maths Education's learners are required to attend two mathematics sessions a week, and they can elect to attend literacy sessions, Lego clubs and human rights workshops in addition to this. The mathematics course started out by opening up the computer lab for Grade 9 learners to improve their mathematics through Khan Academy (which can be found at www.khanacademy.org)

videos and practice activities. It was found, however, that this online platform was too flexible and that learners would often end up doing copious repetitions of the same exercise, or mistakenly doing very difficult work due to incorrectly navigating through the site. It was also found that the videos were often not appropriate to the South African context in terms of language, mathematical processes and writing conventions and culture. In response to this, OLICO Maths Education created its own online mathematics videos using Explain Everything, as part of OLICO Maths Education's own online mathematics course, created with the Moodle platform. This course takes into account the expected level of learners' mathematical proficiency as informed by Spaul and Kotze (2015), which suggests that Grade 7 learners in Diepsloot are three to four grade levels behind in mathematics. Diagnostic mathematics assessments conducted with all Grade 7s at OLICO Maths Education found that the projection was true for the OLICO Maths Education learners, as these learners were roughly three grades behind grade level. The course is also based on the premise that foundational concepts need to be solidified in order for them to be built upon and for new knowledge to be created, and so, for these reasons, core foundational concepts from previous grades are re-taught and, where applicable, linked with grade-level, Curriculum Assessment Policy Statements (CAPS)-aligned work. In line with OLICO Maths Education's vision of using education to ultimately create a more equal society, the content produced by OLICO Maths Education is open-source, meaning that it is freely available to be shared and distributed and can be found at learn.olico.org.

4. Socio-cultural considerations

In any language intervention one must take into account the socio-cultural considerations which may influence it. The main tension existing within the socio-political sphere is the tension between the utility and prestige of the language on the one hand and the heritage or cultural importance of the language on the other.

The economic, political and social utility of English tends to outweigh the value of the development of true additive bilingualism in parents' convictions (Webb, Lafon & Pare, 2010). Furthermore, mother-tongue education (MTE) is a rather taboo topic among many South Africans. It is a reminder of the deliberately oppressive use of MTE during Bantu Education which limited learners' access to English (Plüddemann *et al.*, 2004). South Africa's current LIEP reflects this aversion to MTE, as learners learn through their L1 only from Grades 1 to 3 before switching to English as LoLT. This policy also reflects the "maximum

exposure fallacy" (Brock-Utne in Plüddemann *et al.*, 2004), which is the belief that L2 proficiency is best attained through more exposure to it, albeit at the expense of the L1. As a result, many parents choose to have their children learn through English from as early an age as possible, irrespective of their English proficiency (NEPI in Setati *et al.*, 2002).

As such, resistance from parents and learners to this project was anticipated. At the beginning of the school year, I informed the learners' parents that I would be implementing an optional bilingual mathematics course. The parents believe that it is important to learn English because it is a medium of instruction and because it allows people to communicate everywhere. They also believe that it is important to learn in English, because school subjects are taught in English and school textbooks are in English. However, the parents also believe that it is important to learn African languages because it "is our culture, and our roots". This led to the question of whether it was important or useful to learn in African languages. The first parent to offer an opinion stated that it was not useful because the medium of instruction at school was English. Several parents showed their agreement with this. Following this, another parent suggested that the learners be taught in English, and that the word is then repeated or explained in the L1 to help the learners understand. Several more parents then expressed their agreement with this suggestion. This then served as an opportunity to share with the parents our hopes to create an experimental course where their children would have the opportunity to learn in a similar manner to this, of which the parents were largely supportive. It is worth noting that the good organisational reputation held by OLICO Maths Education, as well as my personal history of working at OLICO Maths Education for the year prior to this intervention, may have positively contributed to the trust and support the parents showed towards this experimental intervention.

Despite the parents' support of the use of translanguaging, most of the learners initially stated they would prefer to learn through English: 70% of learners stated they would prefer to watch the OLICO videos in English, and only 30% would have preferred to watch the videos in their home language. Learners gave various reasons for their answers. The trends in their answers are represented in Tables 1 and 2 below, after which selected reasons from the learners are given.

Table 1: Reasons for No

Reasons for No				
Understand English better than L1	Importance of English	Undecipherable	Multilingual context	Like English (no reason given)
52%	20%	12%	8%	8%

Some of the reasons given for this include:

- It will make it more difficult than it is because I understand English better than my home language.
- Because some of the children they don't understand English they only understand their home language so they must understand English.
- No, because there are some of my language words I don't know like maths in Setswana and Nathalia won't be able to help me.
- I choose 'no', because in the room we speak a lot of languages and watching the videos in English helps a lot when coming to exams.
- Because I only like learning maths in English.

Table 2: Reasons for Yes

Reasons for Yes	
Understand L1 better than English	Translanguaging suggested
90%	10%

Some of the reasons given for this include:

- Because I will be able to know the steps they show, which means I can be able to understand and how to get an answer.
- Because some of the videos we sometimes don't understand them so it is better to watch them in our home language so that we can understand them more.
- Because we can't understand some of the words that are spoken in English but we can have a mix language.

5. Linguistic considerations

Second language acquisition is an integral component of South African education, as the vast majority of learners are required to acquire a second language (usually English) in order to access the curriculum beyond the first three years. However, English is introduced after only three years of schooling, meaning that learners' basic interpersonal communicative skills are still developing, and most of the time they have certainly not developed the cognitive academic language proficiency needed to use English as a language of learning. It is therefore problematic that the South African education system formally assesses understanding through English.

Cognitive processes and social development are facilitated through language (Webb, Lafon & Pare, 2010). As such, the higher one's language competence, the better one's ability is to access and understand information (Webb, Lafon & Pare, 2010). This is especially true in the education context, within which learners' linguistic competence directly affects their ability to grapple with the content and concepts they encounter.

The Department of Basic Education recognises that many learners in South Africa are learning through their L2 (Department of Basic Education, 2011). The CAPS curriculum sets out to equip learners with basic interpersonal communication skills (BICS) in the Foundation Phase (Grades 1 to 3) (Department of Basic Education, 2011) and to build cognitive academic language proficiency (CALP) in the Intermediate (Grades 4 to 6) and Senior (Grades 7 to 9) Phases (Department of Basic Education, 2011). However, it is noted by the Department of Basic Education (2011) that it is unlikely that learners will have CALP from the time they are learning through their L2, as it is stated: "By the end of Grade 9, these learners should be able to use their home language and first additional language effectively and with confidence for a variety of purposes, including learning" (Department of Basic Education, 2011: 8). However, while BICS can be attained within three to five years, CALP can take from four to seven years to attain (Hakuta *et al.* in Valdés, 2004) and up to 10 years or even longer to attain L1-level CALP (Cummins *et al.*, 1998). Clearly this would put any L2 speaker of the LoLT at an immediate academic disadvantage and they would need many years to catch up to their English-L1 peers.

It is therefore of critical importance that high-quality L2 instruction is provided while CALP is developed in the L1, as many CALP skills can be transferred to the L2 once developed (Wababa, 2009). This is illustrated through Cummins' Common Underlying Proficiency (CUP) model and Development Interdependence Hypothesis. This model argues that different languages share the same faculties in

the brain, for example reading strategies, higher-order thinking skills and subject and conceptual knowledge (Cummins in Fitzgerald, 1995). As these faculties are shared among different languages, the CUP model argues that these linguistic skills are transferrable across languages. As L1 knowledge is transferrable to the L2, it is important that learners have solid conceptual knowledge in their L1 (Wababa, 2009). It is, however, also important to note that certain concepts may differ when they are reinterpreted from one language to another (Wales, 1990). Language and culture are deeply intertwined as culture often influences the interpretation of language, and so it is important that these cultural and linguistic matches and mismatches are taken into account when considering the transference of concepts across languages.

6. Mathematical considerations

6.1 *The language of mathematics*

It is often thought that mathematics is one of the easier subjects to learn through an L2 because it is perceived that mathematics is less language-dependent than other subjects. This assumption is, however, incorrect and problematic. Newman (in Wales, 1990) found that Grade 6 learners' mathematical errors often arose from misunderstanding the language used, rather than simply applying incorrect mathematical processes.

A mathematical register does not consist solely of words, but also of a particular way of communicating (Halliday in Pimm, 1991). Furthermore, mathematical English differs from everyday English as words hold different meanings or functions (Pimm, 1991). While there are some words unique to mathematical English, other words are borrowed from ordinary English and altered (Shuard, 1982). Everyday English and ordinary English may cause confusion when words have altered meanings, with the more formal grammar and the actual mathematical symbols (Pimm, 1981). When learners are able to communicate in formal and informal mathematical language, they are able to synthesise spontaneous and technical concepts, and in this way they are able to build mathematical knowledge (Mphunyane in Setati & Adler, 2000).

While mathematics has a certain vocabulary and register associated with it, it is not a language in itself. As such, mathematics needs to be communicated through another language (for example English or isiZulu) (Setati, 2002). It then follows that the learning of mathematics is complicated by learning it through a language in which one is not fluent. An additional complication to mathematical language is that learners may confuse mathematical language with everyday language where the two overlap; for example the words "and", "or", "if ...

then', 'some', 'any', and so on" (Rowland in Setati, 2002:10) seem simple in conversational English, yet they have a very specific and slightly different meaning in mathematical English (Setati, 2002:10). Setati (2002:9) suggests that learners in South African mathematics classrooms encounter many types of languages: conversational English and mathematical English, "formal and informal mathematics language", conversations about procedure and conversations about concepts, and 'leaners' L1s and the LoLT.

When learners are learning in an L2, it is not always possible to differentiate between errors made due to conceptual misunderstanding vs errors due to language proficiency (Moschkovich, 1999). In order to understand and communicate mathematics, learners need the necessary vocabulary and understanding of the written mathematical language (including the signs and symbols), and this mathematical language proficiency is best developed through extensive opportunities for reading, writing and speaking about mathematics (Sfard *et al.*, 1998). Learners process thoughts by communicating and synthesising them into more cohesive ideas (Sfard *et al.*, 1998). As such, talking about mathematics not only provides learners with opportunities to grow their language proficiencies but also to refine and expand their mathematical understanding (Sfard *et al.*, 1998).

6.2 Learning fractions

The mathematics topic used in this project was fractions. This is of particular significance because fractions are renowned for being one of the more complex concepts in primary school mathematics. Learners often struggle with fractions because they do not represent set numbers, as for example natural numbers do, but rather represent relations between different quantities (TLRP, 2006). This is confusing because fractions that look the same could represent different quantities (for example $\frac{1}{2}$ of 4 is different to $\frac{1}{2}$ of 6) and fractions that look different may represent equal quantities (for example $\frac{1}{2}$ and $\frac{2}{4}$) (TLRP, 2006). When learners begin to learn mathematics, they are taught to reject fractions as numbers, because they are not whole numbers (Charalambos & Pitta-Pantazi, 2007), and so this fundamental understanding needs to be overhauled in order for learners to successfully grapple with fractions. Fractions are also seen as particularly difficult because each fraction can be understood in five different ways: as part of a whole, as a ratio, as a quotient, as a measure or as an operator (Pantziara & Philippou, 2012).

7. Methodology

Conducting studies about how people learn requires contextual observations and experiments, and a methodological framework is needed in order to do this effectively (Barab & Squire, 2004). Design-based research (DBR) was selected as the most fitting methodology for this research, because, even though it is context-embedded research, the aim of the findings from the data collected through this methodology is to create educational interventions that are applicable and replicable beyond the context in which they were studied (Barab & Squire, 2004). It is this focus on the real-life context and application that sets DBR apart from methodologies such as laboratory experiments.

Each time the design is altered (even though this is central to DBR), the implementation of the design becomes more synthetic (Barab & Squire, 2004), which could lead to what Brown and Campione refer to as "lethal mutations" (in Collins, Joseph & Bielaczyc, 2004) – where the design is changed in unintended ways through its implementation, thus detracting from the underlying principles of the design. In order to ensure the most important elements were adhered to, the critical elements of implementation (Collins *et al.*, 2004) for this research project were drawn up as follows:

Table 3: Critical elements of implementation

Critical element	How it was implemented
The translanguaging model should be used for all the bilingual videos.	The bilingual resource creator and I worked closely to adapt the videos.
The isiZulu used should be familiar to the learners.	This was done at the discretion of the bilingual resource creator and was evaluated by the external evaluator.
The mathematical meanings conveyed in the English-medium videos should be reflected in the bilingual-medium videos.	This was done at the discretion of the bilingual resource creator and was evaluated by the external evaluator and myself.
Learners must have freedom to choose which course to do.	I spoke to each learner individually to ask them which course they would like to do, placing no pressure on them to choose one course over another.
All learners must do a pre-quiz, and, if they score less than 80%, they must then watch the video and complete a post-quiz.	This was automated on the computers.
Learners must watch the videos in the correct order.	This was automated on the computers.

Critical element	How it was implemented
Learners must know how to use the glossary.	The facilitators and I showed the learners how to use it and checked that they understood the process.

8. Implementation

In an effort to make the OLICO Maths Education course more linguistically accessible to its users (while also ensuring learners acquire the necessary English required for doing mathematics at school), a bilingual mathematics course was run as a pilot. This was for the Grade 7 fractions course, which was started by all Grade 7s at the beginning of the third term, 2015. The course was created in English and isiZulu. IsiZulu was chosen as it is one of the languages spoken by the majority of the OLICO Maths Education learners and for logistical reasons such as staffing and intelligibility to the researcher.

To implement the design, I created a translanguaging model informed by the literature. I then worked closely with the OLICO Maths Education team to jointly create English-isiZulu bilingual videos using the translanguaging model and a bilingual online glossary of mathematics terms. We created the videos using Explain Everything, a video-making application similar to Microsoft PowerPoint, but adapted to online teaching, and we used Moodle as a platform for the online course. The team of people involved in this project include: the mathematics coordinator Dr Lynn Bowie, who has extensive experience working in mathematics education and creates OLICO Maths Educations' mathematics content; the bilingual resource creator Thabiso Simelane, a facilitator at OLICO Maths Education whose L1 is isiZulu; and the project co-founder Andrew Barrett who manages the technological elements and the monitoring and evaluation of the OLICO Maths Education online course. The rest of the OLICO Maths Education team also showed an interest in the project and provided feedback throughout the project.

This research project was discussed with all learners and their parents at the beginning of the year. Before the experiment was begun, permission letters were sent to learners' parents, as the learners were 11 – 14 years old and as such required permission from a parent or guardian. All permission letters were signed and returned. Parents could give permission for learners to participate in the study and to participate in the experimental course. All parents gave permission for their children to participate in the study, but two parents did not give permission for their children to take part in the experimental course. A further level of agency and autonomy was granted to learners, as learners whose parents

had given permission for them to participate in the experimental course could then self-select to participate in the experimental course. All verbal feedback from the learners was voluntary.

When the fractions course began, I spoke to each learner individually to find out whether they would sign up for the English-medium or English-isiZulu bilingual fractions course. I explained the differences between the courses, clarified that informal isiZulu would be used and asked learners which course they would like to do and if they would like to share their reason for their choice with me. At the beginning of the term, learners self-selected to enrol in either the English-medium fractions course or the English and isiZulu bilingual fractions course. Learners then all did the same course, but those doing the bilingual course watched the bilingual videos, had access to the hyperlinked glossary and received a glossary insert to keep in their homework books.

Throughout the course, I had regular discussions with the Grade 7 mathematics facilitators and the learners about how learners were experiencing the bilingual fractions course. As the learners already knew me as a member of the OLICO Maths Education team, my presence as a researcher was less invasive. They also felt comfortable with giving uninhibited feedback and commenting on and evaluating elements of the course at OLICO Maths Education.

The bilingual nature of the course is outlined in the following sections.

8.1 *English-isiZulu bilingual hyperlinked glossary*

This glossary was only made available to learners who enrolled in the bilingual online mathematics course. There was a bilingual glossary available as hyperlinks in all of the fractions pre-quizzes, skills practice quizzes and mixed practice quizzes. Glossary terms that appeared in the bilingual online mathematics course were indicated in blue. Learners could choose to click on any of the hyperlinked glossary terms at any time they came across them in the course. When learners clicked on the term, a pop-up box would open with the English and isiZulu definitions of the term, illustrated by Figure 1:

Figure 1: Hyperlinked glossary

The glossary was created as follows:

1. I selected terms from the mathematics course and homework books based on and informed by observations I had made of learners' understanding of the fractions course in the previous year.
2. I wrote short definitions in English, similar to an explanation I would give to a learner in class, which would be informed by my experience in the subject. Learners were also instructed to read textbooks, watch videos, attend classes, etc.
3. I then passed this list on to the bilingual resource creator, who wrote short definitions in isiZulu, also similar to an explanation he would give to a learner in class. 'Borrowing' (Mawonga, Maseko & Nkomo, 2014), that is, using English terms within isiZulu, and 'paraphrasing' (Mawonga *et al.*, 2014), that is, creating descriptions of the term, were used in the creation of the glossary and the videos. This process was rather basic as the intention was to find a method that is replicable by other teachers with similar linguistic proficiencies and mathematics backgrounds.
4. The project co-founder then uploaded this glossary onto the online bilingual fractions course so that whenever learners encountered one of the words from the glossary they could simply click on it and the short explanations in both English and isiZulu would pop up.

8.2 Homework book: English-isiZulu bilingual glossary

The glossary (see **Figure 2**) used in the course was also printed in the learners' homework books. It was in the form of an additional page stapled into the homework books. It appeared as such:

<div> English-isiZulu Maths glossary</div>	
Convert Change it to something. <u>Kushinye kulenombolo evivo ukwenze iqhezumbulu.</u>	Revise Look at your work and practice it again. <u>Buyekeza Umsebenzi wakho.</u>
Diagram A picture that explains something. <u>Umdwebo o chaza okuthize.</u>	Shaded Made darker or coloured in. <u>Umbala okhangiswe.</u>
Equivalent The same as something else. <u>Okune nani elifinayo kunaleli eliqhathaniswayo.</u>	Share fairly So that everyone gets the same amount. <u>Kuhlukwaniswe ngokulinganayo.</u>
Illustrate Show something using a picture. <u>Khombisa ngokucacile usebenzise isithombe.</u>	Simplest form <u>With the easiest or smallest numbers.</u> <u>Kukhobise ngendlela elula kahulu.</u>
Represent Show something using words or a picture. <u>Khombisa umfanikiso omele amagama noma isithombe.</u>	

Figure 2: Printed glossary

8.3 Bilingual videos

Through careful review of the literature it was possible to create a translanguaging model that synthesises key elements of second language acquisition (SLA) theory. The first premise on which this theoretical framework is based is that we conceptualise in our L1 (Cummins, 1979). This means that when we learn new things or create ideas, we do this in our L1 (where L1 refers to the language in which one is most proficient). This links to Vygotsky's theory (Lantolf & Appel, 1994) that thought is dependent on language and that we need language to facilitate what is commonly called in layman's terms 'the voice inside your head'. In order to facilitate conceptualisation in one's L1, two main factors need to be considered: the input, or how one gains conceptual knowledge, and the output, or how one expresses this knowledge.

Secondly, in receiving information one needs to take into consideration the learner's language proficiency and whether the language being used is context-embedded or context-reduced. As explained by Baker (1993), when one is learning through a L2 one depends on the context to make sense of the content, for example, when meeting someone, one is able to deduce meaning from greetings because those greetings are the expected language practices in that context. In order to understand language that is more abstract or not directly related to the context, as is the case in much of the mathematics curriculum, one needs to have stronger language proficiency in the language being used in order to understand the meaning without relying on the context (Baker, 1993). Therefore in SLA theory it is common to use context-embedded language while learners are developing their L2 and to then move toward context-reduced language as their proficiency improves (Cummins & Swain, 1986). However, it is important to note that in the South African context, where learners are often not proficient in the LoLT, learners are often required to make sense of context-reduced language when school content is more abstract and does not relate to clearly identifiable context. Only once a learner is able to make sense of the language is it possible for conceptualisation to fully take place. Even if the language used in conveying the information is not the learner's L1, the learner is likely to build a fuller mental understanding through their L1.

Third, once conceptualisation has taken place, it is necessary in the context of learning and teaching for this conceptualisation and understanding to be articulated. However, simply because one conceptualises in one's L1 does not necessarily mean one is unable to express these conceptualisations in another language. Indeed, many people express intricate conceptualisations in their L2 on a daily basis. In order to do this, these people make use of what Cummins calls the developmental interdependence hypothesis. This hypothesis states that a person's L2 competence is greatly influenced by their existing L1 competence (Cummins, 1979) and that certain linguistic skills and conceptual knowledge can be transferred from the L1 to the L2 (Cummins, 1979). By extension, this means that if the L1 is already well developed, the L2 will also become well developed at no expense to the L1 (Cummins, 1979). However, if the L1 is underdeveloped there will not be adequate linguistic skills to transfer and aid the development of the L2, resulting in "semilingualism", or poor proficiency in both the L1 and the L2 (Cummins, 1979:231).

When considering how these three theories inform one another, it is clear that different languages can be used in the process of stimulating cognitive activity. While the term 'codeswitching' is used as a broad term for mixing more

than one language, 'translanguaging' is a more apt term in this context. Translanguaging presupposes the use of more than one language, but also goes further to ensure that the languages are conscientiously used to best facilitate the cognition process. This is illustrated in the theoretical framework below (Figure 3), where input is received through the L2 (which is the LoLT), made sense of in the L1, and reproduced in the L2 (LoLT). This theoretical framework informs the creation and analysis of the experiment of this research project.

Figure 3: Theoretical framework

This translanguaging model was to be implemented as such: First, the concept is introduced in isiZulu. The use of the L1 here provides a context for the subsequent input the learner will receive. Once the concept has been clarified, it is expanded on in English. Because isiZulu has been used to introduce the concept and provide some context, the expansion of the concept is context-embedded and easier for the learners to understand. After this, isiZulu is used to introduce the next concept, similarly setting the context. Again, English is then used to expand on this concept. This pattern is repeated throughout the video and finally recapped in English at the end. The aim of this model is to allow the learners to grapple with new ideas and conceptualise the information in their L1, while also giving them the English tools they need in order to be able to recognise, understand and reproduce the concepts in English, as this is necessary at school.

9. Challenges

Because design experiments aim to improve learning, if it is seen that it is not doing so in the desired manner, design experiments can be revised during the process of implementation (Collins *et al.*, 2004). However, to ensure that they still provide valid research from which others may learn and upon which further research can be built, it is important that if something is not working as intended, the reason for it not working is analysed and this reason – along with the measures taken to improve it – are recorded (Collins *et al.*, 2004). In doing so, one does not only provide an accurate and honest account of the experiment, but one also provides valuable information about failures (Collins *et al.*, 2004).

After making the first three videos, the mathematics coordinator put me in touch with a quality assessor, Thulelah Takane, a PhD candidate with isiZulu L1 proficiency whose research focus was language and mathematics. The mathematics facilitator and quality assessor pointed out that the fractions drawn in the video were not divided into equal parts¹ and so the bilingual resource creator edited the video so that fractions were always represented equally (i.e. if one divided a whole into four quarters, each quarter would be of equal size). After the creation of fractions Video 5, the project co-founder pointed out that the English-isiZulu bilingual video was considerably longer than the English-medium video. The bilingual video was about 17 minutes while the English-medium one was around six minutes. The project co-founder suggested that we should try to keep videos below 10 minutes, as he and the mathematics coordinator had found that learners lose concentration when videos exceed this length. The bilingual resource creator and I then discussed why the video was so long. It was initially predicted that the English-isiZulu bilingual videos would be slightly longer than their English-medium counterparts, particularly because much academic vocabulary has not been standardised in African languages (Webb, 2004) and the isiZulu adaptations tend to be slightly longer than the English terms. However, we had not anticipated that the English-isiZulu bilingual videos would be that much longer. In discussion with the bilingual resource creator, we realised that he was speaking slightly slower than the mathematics coordinator spoke in her videos because he wanted to ensure he was fully audible and understandable in the videos. He also explained to me that there were different ways in which to explain certain things in isiZulu and he would sometimes explain something more than once, using different ways of explaining it each time, with the hope that if learners did not understand the first explanation, they would

1 It is important for representations of fractions to be equal so that learners can grasp the idea of equivalent fractions.

then understand a subsequent explanation. In our discussion we spoke about how the mathematics coordinator explains things in one way and that, if learners did not understand the explanation given in the videos, they were aware that they had the opportunity to ask the facilitators to explain it in a different way to them, which they often did. We then decided that the bilingual resource creator would choose an explanation he felt learners were most likely to understand and only use that one. He also decided to look at the time spent on each slide in the mathematics coordinator's videos and align the time he spent on those slides as closely as possible. He then redid Video 5 (again, after a few learners who were ahead had watched it) and implemented the decisions from our discussion in the subsequent videos. As a result, all the subsequent videos were much closer in length to the English-medium videos.

The quality assessor's feedback about the ambiguity of using the term *izikhathi* to reflect fractions speaks to Pimm's (1981) point that translating mathematical language directly into ordinary language is a commonly used technique; however, confusion may arise from its use as mathematical terms often do not have direct and constant equivalent terms in English (or the LoLT). The feedback given by the mathematics coordinator and the quality assessor regarded ambiguities of the language used and the correct explanation of core tenets of the subject as vital in this process and suggested that, if this model of codeswitching were to be applied elsewhere, it would require the creator of the videos to have a sound understanding of the language and the subject, ideally more than any layperson. This would need to be a consideration if one were to scale such a project.

As is seemingly inevitable with many interventions, the technology component also posed a difficulty in the video creation. The bilingual resource creator and I set aside a week in the school holidays to create all the videos, but that week happened to coincide with the re-networking of the computer lab and we were not able to create the videos in that week. As such, we were working on the videos while the course was running. This resulted in us rushing to get the videos up in time, giving us less time to review the videos in more detail before rolling them out in the experiment. Furthermore, several videos consisted of mostly isiZulu audio and did not use as much English as suggested in the translanguaging model. As such, the results of this design experiment are more indicative of the success of a bilingual language model than the specific translanguaging model outlined in this paper. This is an example of the 'messiness' of real-world applications that DBR accounts for and illustrates the importance of the

adaptability of the DBR methodology, as we had to adapt the experiment according to these constraints.

10. Data presentation and analysis

A total of 40 learners participated in the design experiment, with 18 learners in the experimental group (i.e. the group that enrolled in the English-isiZulu bilingual online mathematics course) and 22 learners in the control group (i.e. the group that enrolled in the English-medium online mathematics course). These learners were Grade 7 learners aged 11 to 13. The learners were from four different schools in Diepsloot. The linguistic biography of the learners who enrolled in the English-isiZulu bilingual group is as follows: six learners whose L1 is isiZulu; six learners whose L1 is a Sotho-based language; five learners whose L1 is isiXhosa; and one learner whose home language is Xitsonga. The linguistic biography of the learners who enrolled in the English-medium group is as follows: 17 learners whose L1 is a Sotho-based language; three learners whose L1 is isiZulu; one learner whose L1 is isiNdebele; and one learner whose L1 is Xitsonga.

10.1 *Pre-quiz to post-quiz improvement*

The pre-quiz is an online short quiz of roughly six questions on the lesson topic and determines whether or not the learner has sufficient understanding of the topic. Learners who attained less than 80% for the pre-quiz, indicating that they do not have sufficient understanding of the topic, would then watch the video. Those who attained 80% or more, indicating that they understood the topic, automatically progressed to the next level. Learners who attained less than 80% and watched the video then attempted the post-quiz after the video. The post-quiz checks whether the learner has understood the lesson as explained in the video. To illustrate that they have understood the lesson, learners should attain at least 80%, after which they progress to the next level. In determining the improvement learners showed after watching the video, only the results of the learners who achieved less than 80% for the pre-quiz (and thus wrote the post-quiz) were included.

Effect size was used to ascertain the quantitative differences in this evaluation. This is done by finding the difference in achievement between the experimental and control groups, as well as the standard deviation within these groups, thus illustrating the overall improvement (Coe, 2002).

Ultimately, the quantitative difference in improvement between the experimental and control groups was inconclusive, with the bilingual group showing more overall improvement of an effect size of only 0.01 – which is too small to be meaningful.

These inconclusive results are attributed to the very short space of time over which the experiment was conducted. The minimal quantitative improvement does not, however, indicate a failure of this intervention. Contrarily, it illustrates that learners were able to perform with at least as much improvement as their peers while learning through the language of their choice, which also enhanced learners' motivation and sense of self-worth. A group of four learners commented that sometimes they found it difficult to understand in English and so it was easier for them to understand in isiZulu. They noted that the isiZulu used in the videos made it easier because "it's not that deep Zulu". However, since learners were not familiar with learning through isiZulu, this may also be an aspect in which further improvement may be seen as they are familiarised. And a very important quantitative note to be made is that the project improved learners' enthusiasm about and pride in their home languages. At the beginning of the year, many learners were adamant that they needed to learn in English, but this attitude changed dramatically with the introduction of the bilingual course. I once asked a group of learners in passing conversation what the best part of the term had been and one quickly replied: "We get to learn maths in isiZulu!"

10.2 Glossary use and understanding

The bilingual glossary was available to the learners throughout the quizzes. To measure the efficacy of the glossary I examined the number of clicks per glossary item and tested the learners afterwards to measure their retention of the meaning (Figure 4).

Figure 4: Number of glossary clicks per learner

The above diagram shows how many times each learner clicked on the glossary and also gives a breakdown of how many terms each learner clicked on. While Learner 3 and Learner 11 clicked once each on one and three terms respectively, most learners clicked on one to five terms a number of times each. A noteworthy case is Learner 2, who clicked on *shaded* once, *diagram* twice, *convert* three times and *simplest form* 16 times.

Figure 5 illustrates how many times each glossary was clicked on in total. There are clear differences here, with *equivalent* receiving very few clicks, *convert*, *diagram* and *shaded* receiving a similar number of clicks, and *simplest form* receiving substantially more clicks than any of the other terms.

Figure 5: Number of glossary clicks per term

Figure 6 illustrates the results of the glossary quiz the learners completed after the completion of the experimental course.

Figure 6: Number of correct answers per term

Fourteen of the learners who participated in the experimental course participated in this quiz and are represented above illustrating learners' understanding and retention of the terms learned through the glossary. The findings suggest that the words that were not clicked on were already known by the learners, that the term *equivalent* was already known by most of the learners, that *convert*, *diagram* and *shaded* were unknown to several learners, and that most learners did not understand the meaning of *simplest form*. The fact that most learners who used the glossary clicked on one to five terms several times each could indicate that either the learner did not understand the definition, or that they forgot it. The reason for the term *simplest form* receiving so many clicks could be because of an inadequate revision of the term; because putting an answer into *simplest form* makes the difference between an answer being correct or incorrect; or because the term *simplest form* occurred significantly more often throughout the course than the other glossary items. The word *illustrate* was not known by the learners, despite this being a general language term that is not limited to the mathematics context. The fact that it was not clicked on suggests either that the learners did not deem understanding it to be important or relevant to the work they were doing, or they lacked the meta-cognitive awareness of which words they did and did not understand.

The experimental glossary improved learners' language proficiencies as they recalled many of the terms they had clicked on. The glossary furthermore facilitated a change in their attitude towards using their L1 in the mathematical context, as several learners chose to use their home language to explain the English terms. It is interesting to note that isiZulu and isiXhosa speaking learners wrote in their L1s more readily than had ever been noted in a written task at OLICO Maths Education. The fact that learners successfully used their L1s to explain terms illustrates that learners believe their languages are suitable for use in mathematics. This is contrary to the commonly held belief, noted by Probyn (2009) and evidenced by the learners prior to the experiment, that African languages have insufficient terminology to be used in mathematics. The learners' use of their L1s to explain the glossary terms also illustrates their (albeit perhaps surface-level) understanding of the use of language for cognitive activity, which Titone (1978) cites as an important role of multilingual education. This also indicates that learners can benefit greatly from the use of multilingual teaching resources such as this glossary, as these resources equip learners with the linguistic knowledge needed to facilitate conceptual development.

Learners' positive feedback and evident enthusiasm throughout the experiment contrasted sharply with the attitudes expressed in the pre-course surveys. This positive attitude towards their L1 appeared, however, to be short-lived as learners only actively advocated using their L1 in learning mathematics when this was available to them as an option. After the experiment, when learners returned to learning in English, most learners once again argued that they should be learning through the medium of English. This illustrates that learners' motivation for their choice of LoLT is not necessarily influenced by knowledge of the relation between language and cognition, but rather by hegemonic language in education practices.

11. Recommendations and conclusion

This research has detailed the impetus, creation and evaluation of a bilingual education intervention in Diepsloot, Johannesburg, South Africa. While the period in which this research was conducted was too short to yield a large number of quantitative results, the qualitative results illustrated learners' improved motivation to learn and take pride in their L1s. The multilingual resources detailed in this research project were successful and are replicable, and it would be beneficial to replicate the videos, glossary and translanguaging model (as illustrated in the theoretical framework) throughout the different South African contexts. South Africa has very different language environments, from linguistically homo-

genous rural areas where only one language is spoken, to highly multilingual environments such as Diepsloot. These contexts naturally impact the results. Furthermore, DBR is an iterative process that requires further iterations of the design to be carried out and analysed, such that in this case the translanguaging model could be refined.

As argued by Cummins and Swain (1986), the use of the learners' L1 asserts their pride in their identity, and as argued by Benson (2004), it promotes the status of the language. This was clearly illustrated by learners' positive reactions to learning in isiZulu and also later by learners requesting a similar experiment using their various L1s. Learners' enthusiastic lobbying for the experiment to be conducted again in all languages, and not only their own L1s, illustrates Lindholm's (in Lindholm-Leary, 2001) point that additive bilingualism also fosters learners' embrace of other cultures. Several learners who had elected to do the English-medium course later said they would like to do a course through the medium of isiZulu or their home language after seeing the experimental course. This is encouraging and could indicate that learners felt motivated by seeing their friends doing the experimental course, or that their preconceptions about the type of language that would be used differed to the actual language use. That learners then said they would prefer to watch the videos in English in the post-video surveys suggests that learners got excited about it in the moment but lost enthusiasm when it was not a current or tangible event. This may illustrate that, while the experimental course did improve learners' enthusiasm, this enthusiasm may not be sustainable as for some learners it is extrinsic and dependent on external factors such as the novelty and newness of the course rather than intrinsic motivation and desire to learn in their L1.

By incorporating learners' L1 into teaching and learning, South Africa's education system could provide learners with a better understanding of classroom content, while simultaneously affirming learners' linguistic and cultural identities and opening a space for intercultural understanding. Learners' improved understanding of classwork would not only lead to improved test results and pass rates, but would also lead to improved life prospects as new opportunities become available to these learners in both the educational and socio-economic spaces. This in turn would allow for greater socio-economic mobility and greater equality of opportunity for all of South Africa's learners.

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