CODESWITCHING ONLINE:
A CASE STUDY OF A BILINGUAL ONLINE MATHS PROGRAMME FOR GRADE 7 LEARNERS IN DIEPSLOOT, JOHANNESBURG

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by

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Abstract

There is an education crisis in South Africa. Mathematics and literacy are at the forefront of the problem, as particularly evidenced by Annual National Assessment results (Department of Basic Education, 2014; Spaull, 2014). This research is motivated by the unequal access to quality learning which stems from learners learning through a poorly-understood second language with little to no cognitive academic language proficiency.

The vast majority of South African learners learn through their second language, English, from Grade 4 onwards. English is the language of South Africa's political economy and is a global lingua franca; however, the understanding of concepts and content learnt at school is vital if one is to have any hope of putting one's English to good use. This research aimed to find a way to equip learners both with English proficiency and mathematical understanding simultaneously. This was done by implementing and evaluating an experimental bilingual course in an existing mathematics programme in the township of Diepsloot in Johannesburg, South Africa.

This research used design-based research methodology, using both qualitative and quantitative research methods. This methodology was chosen as it allows theory and practice to intersect in a real-life setting, and for the successes and shortcomings of this intersection to be evaluated.

This study encompasses both the evaluation and creation of the bilingual online mathematics course. The course is made bilingual through the creation of bilingual videos with the use of translanguaging and the creation of a bilingual glossary of terms. The videos were created using a translanguaging 'model' informed by theories of basic interpersonal communication skills and cognitive academic language proficiency (Cummins, 1981), common underlying proficiency (Cummins, 1991), codeswitching (Setati, 1998; Ncoko *et al.*, 2000) and translanguaging (Makalela 2015; Creese and Blackledge, 2010a).

The aim of this research was to create a successful translanguaging model which facilitates learners' ability to conceptualise in their first language and then discuss and understand the concept in their second language.

Isishwankathelo

Isimo semfundo eMzantsi Afrika simandundu. IMathematika nobugcisa bokufunda nokubhala zezona ziphambili kule ngxaki njengoko kubonakaliswa ziziphumo ze-Annual National Assessment (Department of Basic Education, 2014; Spaull, 2011). Olu phando luphenjelelwe kukufikelela kwababafundi ngokungalinganiyo kwimfundo esemgangathweni, nto leyo idalwa kukuba abafundi befunda ngolwimi abangaluqondi kakuhle kuba ilulwimi lwabo lwesibini ze, ngenxa yoko, bangalunqondi ngokupheleleyo, okanye baluqonde kancinci ulwimi lobugcisa nolufuna ingqiqo ephezulu, olusetyenziswa kwezemfundo.

Uninzi lwababafundi eMzantsi Afrika lufunda ngolwimi lwabo lwesibini, olusisiNgesi, ukuqalela kwiSigaba sokuQala ukuya phambili. IsiNgesi lulwimi lwezoqoqosho nezopolitiko eMzantsi Afrika, ikwalulwimi elinxibelelana ngalo ihlabathi; kodwa nangona kunjalo ingqiqo noko kufundwayo esikolweni zibalulekile ukuba ubani ufuna ukusisebenzisa kakuhle esi siNgesi. Olu phando lujonge ekufumaneni indlela yokuxhobisa abafundi ngesiNgesi nobugcisa bokuqonda imathematika. Oku kwenziwe ngokusebenzisa nokuhlola ukusebenza kwekhosi elwimi-mbini kwinkqubo yeMathematika ebisele ikho kwilokishi yaseDiepsloot eRhawutini, eMzantsi Afrika.

Olu phando lusebenzise isicwangciso sokwenza uphando esiyidesign-based research methodology, kusetyenziswa izimvo zabo bathatha inxaxheba kuphando kunye neenkcukacha zamanani. Esi sicwangciso sophando sikhethwe kuba sikwazi ukudibanisa ithiyori nesimo sentlalo sokwenyani, ze impumelelo neziphako zaso zivavanywe.

Olu phando luquka ukuvavanywa nokudalwa kwekhosi yemathematika eku-intanethi esebenzisa iilwimi ezimbini. Le khosi yenziwe lwimi-mbini ngokuthi kwenziwe iividiyo ezingeelwimi ezimbini, kusetyenziswa iilwimi ezimbini ngengqiqo (translanguaging) nokwenziwa kwesichazi-sigama esilwimi-mbini. Iividiyo zidalwe ngokusebenzisa umfuziselo wetranslanguaging, kulandelwa ithiyori yebasic interpersonal communication skills (ubugcisa obungundoqo kunxibelwalo) kunye necognitive academic language proficiency (ubugcisa bolwimi obubonisa ingqiqo kumanqanaba aphakamileyo emfundo) (Cummins, 1981), icommon underlying proficiency (ubugcisa obusisiseko) (Cummins, 1991), nokusebenzisa iilwimi ezahlukileyo kwintetho enye (codeswitching) (Setati, 1998; Ncoko et al., 2000) netranslanguaging (Makalela 2015; Creese and Blackledge, 2010).

Injongo yolu phando ibikukudala umfuziselo onempumelelo wetranslanguaging ekhuthaza abafundi ukuba bazuze ingqiqo yomxholo ofundwayo ngolwimi lwabo lweenkobe, ze baxoxe ngaloo mba ufundiswayo, futhi bawuqonde ngolwimi lwabo lwesibini.

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List of acronyms and abbreviations

ANAs	Annual National Assessment
BICS	Basic Interpersonal Communication Skills
BODMAS	Brackets Of Division, Multiplication, Addition and Subtraction
CALL	Computer-Assisted Language Learning
CALP	Cognitive Academic Language Proficiency
CAPS	Curriculum and Assessment Policy Statement
CUP	Common Underlying Proficiency
DBR	Design-Based Research
DET	Department of Education and Training
EFL	English Foreign Language
ESL	English Second Language
iOS	Apple Operating System
L1	First Language
L2	Second Language
LED	Light-Emitting Diode
LiEP	Language in Education Policy
LoLT	Language of Learning and Teaching
MTE	Mother Tongue Education
NGO	Non-Governmental Organisation
NPO	Not-for-Profit Organisation
OLICO	Open Learning In Community
PDF	Portable Document Format
PhD	Doctorate of Philosophy
PIRLS	Progress in International Reading and Literacy Study
SD	Standard Deviation
SGB	Student Governing Body
SLA	Second Language Acquisition
SPCA	Society for the Prevention of Cruelty to Animals
TLRP	Teaching and Learning Research Programme

Chapter 1: Introduction

Education is important – this is common knowledge. It is therefore odd that access to education in South Africa is still so unequal. This inequality takes a variety of forms. A prevailing form of unequal access to education is the language of learning and teaching (LoLT), which is a second language[1] (L2) for 90.4% of South Africa's population (Statistics South Afr, 2012: 24).

The impetus for this research project stemmed from a culmination of research and previous experience. My life experiences and isiXhosa studies at Rhodes University led me to value multilingualism for its cognitive and psychological benefits. I had examined the codeswitching practices of Grade 4 Mathematics and Natural Science and Technology teachers at a Grahamstown school for my Honours research project (von Witt, 2013). This experience combined with the literature informed a suggested codeswitching model to allow learners to understand concepts in their first language (L1) while also developing their English proficiency. I was then given the opportunity to work with OLICO Youth, a non-governmental organisation (NGO)/non-profit organisation (NPO) in Diepsloot that provides computer-based after-school mathematics support. It appeared as a perfect opportunity to test the efficacy of the model in video form. These videos were then created and implemented, after which it was found that quantitatively no significant difference was made, and qualitatively very little difference was made.

The creation of this design experiment and its results are explained in this research paper through socio-political, linguistic, mathematical and personal lenses. The findings of this analysis show that the experiment is meritorious and should be further developed in line with the recommendations made in this research, and that further iterations of this experiment should be implemented over a longer period in a variety of contexts.

This design experiment puts research into practise in the hope that it will be reiterated in different contexts and continuously refined and improved. If this comes to fruition it may be possible for successful codeswitching models to be used in similar education programs, by teachers in the classroom and in the design of support materials. This may be achieved through the creation of teacher training programs and through influencing language policy toward being more inclusive of multilingualism and informed codeswitching.

[1] Second language here refers to a language learnt in addition to the first language.

1.1 Context

1.2.1 South Africa

With South Africa's history and evident legacy of apartheid, the group of learners learning through their L2 largely corresponds with the black African race group oppressed by apartheid. These learners fight an uphill battle from when they first start school with rural and township families often struggling to support their families financially. Many learners from townships and rural areas will be the first in their family to finish high school (Statistics South Africa, 2012: 53). For learners who successfully finish high school, it is hoped that their education will give them access to the socio-economic mobility needed to make South Africa a more equal country.

From Grade 4 onwards English is the primary LoLT, despite this being an L2 to 90.4% of South Africa's population (Statistics South Africa, 2012: 24). With this switch in LoLT happening 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: 9) making it difficult for them to have meaningful engagement with the curriculum context. Many schools in South Africa barely have necessities such as adequate sanitation and textbooks (Metcalfe, 2015: 145), and so it follows that good-quality learning resources, and in particular supplementary learning aids, are few and far between. This accentuates the problem presented by learning in a language in which one is not proficient, and motivation for children to learn is drastically minimised. 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.

South Africa's annual assessments from which much national education-related data is drawn are the Annual National Assessments (ANAs). The ANAs test Grade 1 to 6 and Grade 9 learners in Mathematics, Home Language and First Additional Language. These subjects are chosen as they represent numeracy and literacy, which are seen as key learning areas. The emphasis on these subjects is seen in the weekly time allocated to them within the Curriculum Assessment Policy Statements (CAPS), which is as follows for the Senior Phase (Grades 7 to 9):

SUBJECT	HOURS
Home Language	5
First Additional Language	4
Mathematics	4,5
Natural Sciences	3
Social Sciences	3
Technology	2
Economic Management Sciences	2
Life Orientation	2
Creative Arts	2
TOTAL	**27,5**

(Department of Basic Education, 2011: 7)

Figure 1: Subject weighting for the Senior Phase

The first implementation of the ANAs was in February 2011, and they have been written on an annual basis again in 2012 to 2014. They were not, however, written in 2015 due to teachers' grievances with the ANAs, with this being an illustration of the turbulent climate of education in South Africa. These tests are conducted nationally with the purpose of providing a national overview of learners' strengths and shortcomings within numeracy and mathematics (Department of Basic Education, 2014: 6). These assessments are nationally standardised, but they are not externally evaluated (Spaull, 2014: 303), that is to say all learners throughout South Africa write the same tests but the marking is generally done within the schools. The ANAs are conducted with the intention that through having the results readily available to the Department of Basic Education, schools, teachers, learners and parents, shortcomings can be identified and suitable intervention strategies implemented (Department of Basic Education, 2014: 6). However, the ANAs also face criticism for becoming a focal point of the curriculum, and for not being comparable longitudinally, for example:

> [T]he Grade 3 literacy score improved from 35% in 2011 to 52% in 2012 (a 49% increase), which would make South Africa the fastest improving country in the history of standardised assessments around the world. More plausibly, the tests between 2011 and 2012 are not legitimately comparable.
> (Spaull, 2014: 302)

The schooling system in South Africa remains highly unequal. The schools are differentiated by how they are funded: ordinary government schools are funded by the government; student governing body (SGB) schools receive government funding and subsidise this with school fees; and independent schools receive no funding from the South African government. Ordinary government schools are often also referred to as or likened to ex-DET schools, where DET (Department of Education and Training) refers to government schools for people of colour during apartheid. SGB schools are often referred to as or likened to ex-Model C schools, which were schools for white learners during apartheid, with very limited access for learners of other racial groups. The lack of notable difference between the quality of learning and racial distribution of learners between these types of schools has not changed considerably since the end of apartheid. Both ordinary government and SGB schools follow the CAPS curriculum set by the Department of Basic Education and partake in standardised national testing in the form of the ANAs and Matric examinations, while independent schools generally do not.

It is generally found that learners at government schools are taught an African Language as Home Language throughout primary and high school, while SGB and independent schools teach English or Afrikaans as Home Language and African languages are offered as First Additional Languages. However, there is no clarification made of which learners take their L1 as Home Language and which take their L1s as First Additional Language, and this confounds the results of the ANAs.

1.2.1.1 Literacy

The Department of Basic Education recognises that many learners in South Africa are learning through their L2 (Department of Basic Education, 2011: 8). 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: 8), 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: 9). However, it is noted by the Department of Basic Education (2011: 8) that it is unlikely that learners will have proficiency in 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).

As the majority of South African learners attend ordinary government schools, the First Additional Language marks are most representative of learners from townships or rural areas who learn English as First Additional Language. Considering the ANA results it is clear that many learners are not adequately equipped with the English proficiency needed to grapple with the school subjects which they are taught through the medium of English.

Learners in Grade 6 scored on average 63% for Home Language and 45% for First Additional Language (Department of Basic Education, 2014: 41). In Grade 9 this drops to 48% for Home Language and 34% for First Additional Language (Department of Basic Education, 2014: 41). 77% of Grade 6 learners and 48% of Grade 9 learners attained 50% or more for the Home Language assessment (Department of Basic Education, 2014: 44), while 42% of Grade 6 learners and 18% of Grade 9 learners attained 50% or more for the First Additional Language assessment (Department of Basic Education, 2014: 45). This could be attributed to the increasing difficulty of the language subjects in the higher grades and foundational deficits becoming more apparent with this progression.

1.2.1.2 Mathematics

As per the CAPS requirements, Mathematics in the Senior Phase is comprised of the following five content areas: "Numbers, Operations and Relationships; Patterns, Functions and Algebra; Space and Shape; Measurement; and Data Handling" (Department of Education, 2011b: 9). Different emphases are placed on these content areas from one grade to another. The weight placed on each of these content areas is illustrated below:

WEIGHTING OF CONTENT AREAS			
Content Area	**Grade 7**	**Grade 8**	**Grade 9**
Number, Operations and Relations	30%	25%	15%
Patterns, Functions and Algebra	25%	30%	35%
Space and Shape (Geometry)	25%	25%	30%
Measurement	10%	10%	10%
Data Handling	10%	10%	10%
	100%	**100%**	**100%**

(Department of Education, 2011b: 11)

Figure 2: Weighting of content areas in Senior Phase Mathematics

While the same content areas are covered throughout the Senior Phase, more weight is placed on Numbers, Operations and Relations in Grade 7, Patterns, Functions and Algebra in Grade 8, and Space and Shape (Geometry) in Grade 9. This illustrates how concepts are introduced at various points in the curriculum and then revisited and built on in later grades. Acquiring higher order thinking skills and knowledge is based on building upon foundational knowledge and skills (Spaull and Kotze, 2015: 14), which may be acquired through learning at school, at home, or through lived experiences. Many of learners' difficulties with mathematics stem from learning deficits acquired early in their education, with this being the case particularly for learners in developing countries (Spaull and Kotze, 2015: 13). These deficits are evident from early grades, as only 16% of Grade 3s in South Africa perform academically at grade level (Spaull and Kotze, 2015: 16), and in Gauteng 26% of Grade 3s perform at Grade 3 level (Spaull and Kotze, 2015: 17). In this case, 'grade level' is determined by finding the average performance of learners in Quintile 5 schools, that is, the wealthiest 20% of learners in South Africa (Spaull and Kotze, 2015: 19). This is appropriate as a benchmark because these learners are more likely to be accessing the curriculum through their L1, or else they likely have L1 proficiency in the LoLT, these learners are less likely to be negatively impacted by socio-economic factors, and they are also most likely to receive strong schooling support at home as their parents likely received quality education (as opposed to the education received by parents who learnt under Bantu education).

As the LoLT in Grade 3 is still the learners' L1 this points to grave deficits in the education the learners are receiving, for the most part without L2 instruction factoring into this (Spaull and Kotze, 2015: 16). Spaull and Kotze (2015: 21) calculate that Quintile 1, 2 and 3 learners are on average three grade levels below the benchmark set by Quintile 5 learners for Grades 3 to 6. In Grade 9 learners from Quintiles 1 to 3 are on average more than four grade levels below the Quintile 5 benchmark (Spaull and Kotze, 2015: 21). Considering the learning trajectories of these calculations, Spaull and Kotze (2015: 21) calculate that at a Grade 12 level Quintile 1 to 4 learners would perform on average 4.9 grade levels below their Quintile 5 counterparts.

The reality of these projections is illustrated in the ANAs. In the 2014 ANAs learners scored on average 43% for mathematics in Grade 6, but only 11% for mathematics in Grade 9. (Department of Basic Education, 2014: 41). 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: 42). 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.

1.2.2 Diepsloot, Gauteng

Diepsloot is a township in northern Johannesburg, South Africa. Diepsloot is notorious for its violence and vigilantism, illustrated in particular by the xenophobic violence in 2008 and the kidnapping, rape and murder of two toddlers who were found in a public toilet in 2013; however, little more than this is presented in mainstream media. Diepsloot was planned and created by the apartheid government in the early 1990s (Bénit, 2002: 47), and has grown rapidly with an estimated current population of around 200 000 (Cross, 2014: 143). Within Diepsloot itself the standard of living varies, particularly between Extension 1 and the other areas of Diepsloot. While the rest of Diepsloot was built to house permanent settlement, Extension 1 (also known as the Reception Area) consists mostly of shacks as it is intended for temporary settlement while permanent housing is sought (Bénit, 2002: 48). Ironically, Diepsloot is situated in close proximity to Dainfern, one of Johannesburg's wealthiest suburbs, and Steyn City, a very large and upmarket estate. 97% of Diepsloot's population is black African, and almost 20% of Diepsloot residents are foreign nationals (Mahajan, 2014: 11). Many people live in or move to Diepsloot because of its proximity to work opportunities in relation to other townships, resulting in 70% of the population being of working age, a figure higher than all other areas in South Africa (Mahajan, 2014: 11). The unemployment rate (not including discouraged workers) in Diepsloot is 30%, and 80% of the income generated by Diepsloot residents is in the form of wages and salaries, with pensions and social grants accounting for the remaining 20% (Mahajan, 2014: 11). As a result of people moving to Diepsloot in search of economic opportunity, the mix of language and cultures is extremely diverse, with speakers of many South African and international languages living in Diepsloot. There are 13 schools in Diepsloot, two of which are independent or SGB schools while the others are all government-funded schools (Cross, 2014: 143). Around 6% of Diepsloot residents have received vocational training or tertiary education, and 26% of people in Diepsloot between the ages of 7 and 25 started but did not complete primary school (Mahajan, 2014: 11).

1.2.2.1 Literacy

Diepsloot is a good reflection of the multilingual country in which it is situated. There are speakers of the vast majority, if not the entirety, of South Africa's 11 official languages, as well as many foreign nationals who add to this large number of languages. The lingua franca in Diepsloot is fluid, changing from Sepedi to isiZulu to Sesotho to isiXhosa and so on, depending on the people, the area of Diepsloot, or the context of the conversation.

Many of the schools 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 schoolchildren 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.

In 2014 South African Grade 6 learners scored on average 63% for Home Language, and 45% for First Additional Language (SAQA, 2014: 9). The Gauteng province scored higher than average with 64.6% and 54.5% for Home Language and First Additional Language respectively (SAQA, 2014: 59-60). This illustrates that as these language subjects become more cognitively demanding learners are less able to keep up with the cognitive demand, arguably from the increase in context-reduced language and an inadequate foundation in their L1. The ANA report (SAQA, 2014: 11) cites learners' difficulty in using their own words, their inability to interpret sentences and give their own opinion, and their lack of editing skills as major contributing factors to this poor achievement. The ability to use one's own words and give one's opinion both necessitate the use of CALP to some degree, and naturally if a learner's language proficiency has not yet reached this level learners will struggle with such tasks.

1.2.2.2 Mathematics

In 2014 South African Grade 6 learners scored on average 45% for Mathematics (SAQA, 2014: 9), with the Gauteng province achieving higher than the average at 51.1% (SAQA, 2014: 58). This illustrates that learners are not able to keep up with the increasing difficulty of the mathematics curriculum. The report cites this drop in performance as the result of learners' unfamiliarity with mathematics terminology, basic algebra, and inability to manipulate space in geometry (SAQA, 2014: 11). Unfamiliarity with mathematics terminology is in large part a language-related issue, and if learners are unable to access the language in which they are being taught it is little wonder that learners struggle to grapple with more abstract concepts such as algebra and geometric manipulations.

1.2.3 OLICO Youth

OLICO Youth is a not-for profit non-governmental organisation which runs an after-school academic support programme situated in Diepsloot. OLICO Youth was created with the vision of living "in an inclusive, just and humane society without poverty" (OLICO Foundation NPC, 2015). As is commonly understood, quality education is necessary for quality post-school opportunities which lead to post-school employment, which in turn has the potential to provide the socio-economic mobility needed to eradicate poverty. OLICO Youth began by implementing a mathematics support programme in 2012, and has since also implemented a literacy support programme in 2014. Mathematics was chosen as a key subject requiring extra support, firstly because good performance in mathematics is necessary to access many quality post-school opportunities, and secondly because of the poor mathematics results seen in South Africa, as evidenced by the ANAs. Literacy was later added as a key subject to be supported because of the importance literacy plays in accessing knowledge throughout the school curriculum, post-school opportunities, and in the working world, and also because of the poor literacy results illustrated, for example, in the ANAs.

OLICO Youth is situated in the Bophelong Centre, which is a community centre in Diepsloot run by the Bryanston Methodist Church. This centre is in relatively close proximity (five to 15 minutes walking distance) to several schools in Diepsloot. OLICO Youth has one open-plan homework room and library, and shares a computer lab with the neighbouring Siyakhula Computer School. In 2015 there were roughly 100 learners from Grades 7 to 11 enrolled at OLICO Youth, and every year another class of Grade 7 learners is enrolled. OLICO Youth is run on donor funding, but a fees contribution of R50 per month is asked of all parents. Fees are charged so that learners and parents take seriously the commitment to the programme, and it is found that R50 a month is affordable for many parents. Full and partial bursaries are also offered, with the only requirement being that the parents speak to one of the OLICO Youth staff to complete a bursary form. Several learners are on bursaries.

Learners are required to attend three sessions a week. The learners attend for an hour a day on Monday and Wednesday or Tuesday and Thursday. All learners attend on Saturday mornings where workshops on personal development, life skills and creative expression are held. The literacy programme is optional and learners may elect to enrol in weekly Reading Club or Magazine Team sessions in addition to their compulsory mathematics and life-skills sessions. The mathematics sessions are computer-based and take place in the computer lab, facilitated by two facilitators. The literacy sessions and life-skills sessions are generally not computer-based and take place in homework room. Learners are also encouraged to make use of the homework room and the library to do their school homework and projects and to read. Emphasis is placed on creating a community of learning, and as such learners' academic achievement does not determine learners' acceptance into the programme. Learners' attendance is the only requirement for remaining in the programme, and all learners are expected to attend at least 75% of their mathematics and life-skills sessions. In order to meet this attendance requirement, learners may attend 'catch-up sessions' throughout the week by joining another class's afternoon mathematics session if they are absent for their sessions. Learners with low attendance are placed on probation after which they are either accepted back into the programme or excluded, depending on their commitment to attending well in the future.

The mathematics course started out by opening up the computer lab for Grade 9 learners to improve their mathematics by using 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 Youth created its own online mathematics course, which can be found at learn.olico.org. This course takes into account the expected level of learners' mathematical proficiency as informed by Spaull and Kotze (2015: 21), which suggests that Grade 7 learners in Diepsloot are three to four grade levels behind in mathematics. 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 in with grade-level, CAPS-aligned work. While the concepts and skills listed in fig. 3 are required to be taught in Grades 4, it was clear in diagnostic tests written by the OLICO Youth Grade 7s that these concepts were not fully understood.

TOPICS	GRADE 4
1.2 Common Fractions	**Describing and ordering fractions:** • Compare and order common fractions with different denominators (halves; thirds, quarters; fifths; sixths; sevenths; eighths) • Describe and compare common fractions in diagram form **Calculations with fractions:** • Addition of common fractions with the same denominators • Recognize, describe and use the equivalence of division and fractions **Solving problems** • Solve problems in contexts involving fractions, including grouping and equal sharing **Equivalent forms:** • Recognize and use equivalent forms of common fractions (fractions in which one denominator is a multiple of another)

(Department of Basic Education, 2011c: 16)

Figure 3: Grade 4 concepts in Mathematics

The online mathematics course was created using Moodle, an online platform that is designed with the purpose of being more self-explanatory, with fewer options for learners to mistakenly navigate to the wrong place. This is achieved by having a highly automated course where activities only open once necessary preceding activities have been completed. This means that facilitators are present to assist learners with queries, but that the learners are generally able to self-navigate through the course. OLICO Youth also created their own videos so that the videos can be more relevant to the South African learners' contexts, and so that they can focus specifically on each element of the OLICO Youth mathematics course. The creation of this online mathematics course has been viewed as an iterative process, which has been constantly reviewed and expanded, and as such is still in the process of creation at the time of writing. In line with OLICO Youth's vision of using education to ultimately create a more equal society all of the content produced by OLICO Youth is open-source, meaning that it is freely available to be shared and distributed.

1.2.3.1 Literacy

OLICO Youth's language policy emphasises the use of English and the promotion of multilingualism. English is encouraged because it is the LoLT for all its learners, both at school and at prospective post-school opportunities. However, OLICO Youth recognises the importance of multilingualism from language development, personal development and cultural identity perspectives. A facilitators' handbook is used by facilitators to guide their language use such that English and the learners' home languages are used in a manner that promotes conceptual development and English proficiency.

At OLICO Youth it has been observed that most learners are familiar with English and have basic to fully-developed basic interpersonal communication skills (BICS). However, few learners have developed CALP in their L1, and even fewer learners have developed CALP in English. This is in line with the prediction made by the Department of Basic Education (2011: 8) that learners are unlikely to develop CALP in their L2 before Grade 9. This is evidenced by learners' inability to express how they figured something out and learners' inability to articulate what they are struggling with when they do not understand something. In conversation about mathematics learners seldom explain how or why they are doing something; in place of this they simply name the procedures they are following.

The prestige of English is well-known to the learners, with many OLICO Youth learners citing it as their favourite language irrespective of their proficiency in it. Some learners also cite their home language as their favourite subject, because they are good at it or can identify with it, while others feel that learning it at school is a waste of time. In the Magazine Team programme, in which learners write their own stories and articles, many learners choose to write in English, although the use of a mixture of English and their home language(s) is showing increasing prominence and popularity among the learners.

1.2.3.2 Mathematics

The Grade 7 online mathematics course covers the following topics (listed in chronological order) during the course of the year: whole numbers, quick calculations, times tables, exponents, factors and multiples, fractions, decimals, percentages and measurement. Each of these topics is divided into several lessons, with each lesson focusing on a different element of the topic. For example, the whole numbers course is split up into the following seven lessons:

Whole numbers	
Lesson number	Lesson topic
1	BODMAS
2	Number sizes, place value and rounding
3	More on place value and rounding
4	Column addition
5	Column subtraction
6	Column multiplication
7	Short division

Figure 4: Topics in the OLICO Youth online course

Each course is clearly set out in the same format, and learners are all introduced to and oriented around the format at the beginning of the year. This format is packaged as a specific set of processes for each lesson, and is done so with the intention of ensuring that learners are always doing work appropriate to their level of understanding. These processes are referred to as “The 5 Ps” and consist of the Skills **P**re-quiz, **P**resentation, Skills **P**ost-quiz, and Mixed **P**ractice quiz. These lessons and processes are illustrated and explained below, using the *Working with Whole Numbers* module as an example. All topics and lessons are in English, except for the experimental Fractions course which will be explained later. The classes are conducted primarily in English, although facilitators and learners sometimes use their L1s in discussions.

1. Skills **P**re-quiz

This is a short quiz that checks the learners' existing understanding of the lesson, and helps the learner to check what they know, appearing as follows in figs. 5 and 6:

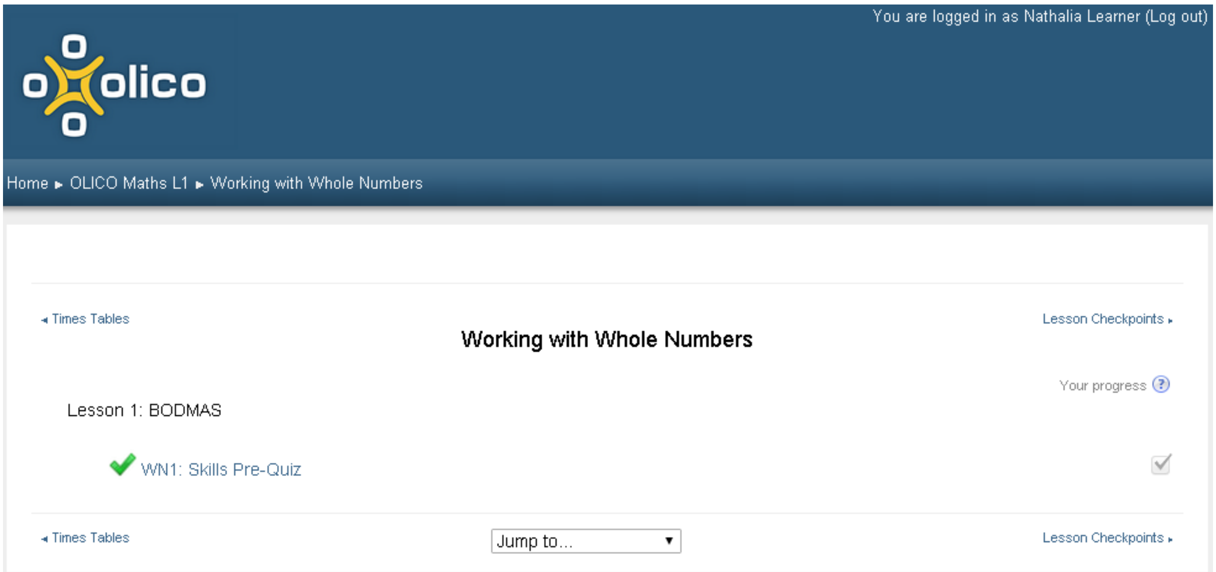


Figure 5: Skills pre-quiz (1)

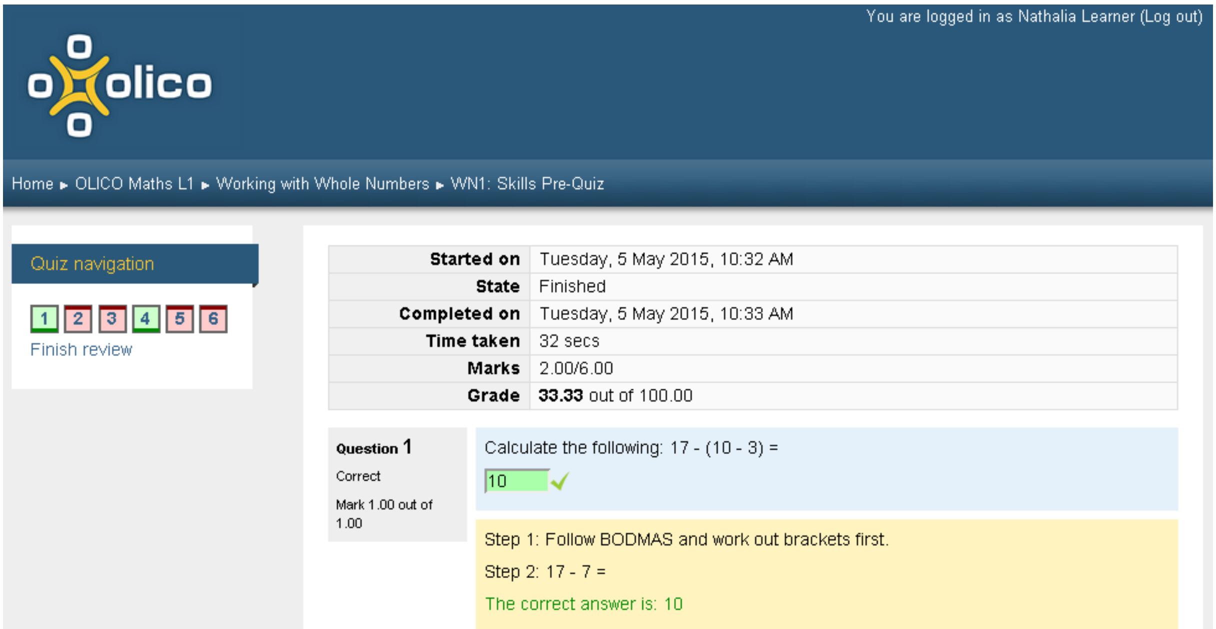


Figure 6: Skills pre-quiz (2)

The pre-quiz determines whether a learner already knows a topic and should proceed to the next topic, or is not proficient in the topic and should complete the rest of the lesson around that topic. For example, if a learner achieved 80% or more for the *Lesson 1: BODMAS* pre-quiz, they automatically skip the video and the skills post-quiz, as it is deemed that they already understand this content. The learner then moves on to the *Lesson 1* mixed practice quiz (explained in point 4 below), after which they move on to *Lesson 2:Number*

Sizes, Place Value and Rounding. If a learner scores less than 80% the presentation will automatically unlock and the learner should continue with the lesson by watching the video.

2. **P**resentation

The presentation consists of a video created by one of the OLICO Youth content developers, and appears as follows in figs. 7 and 8:

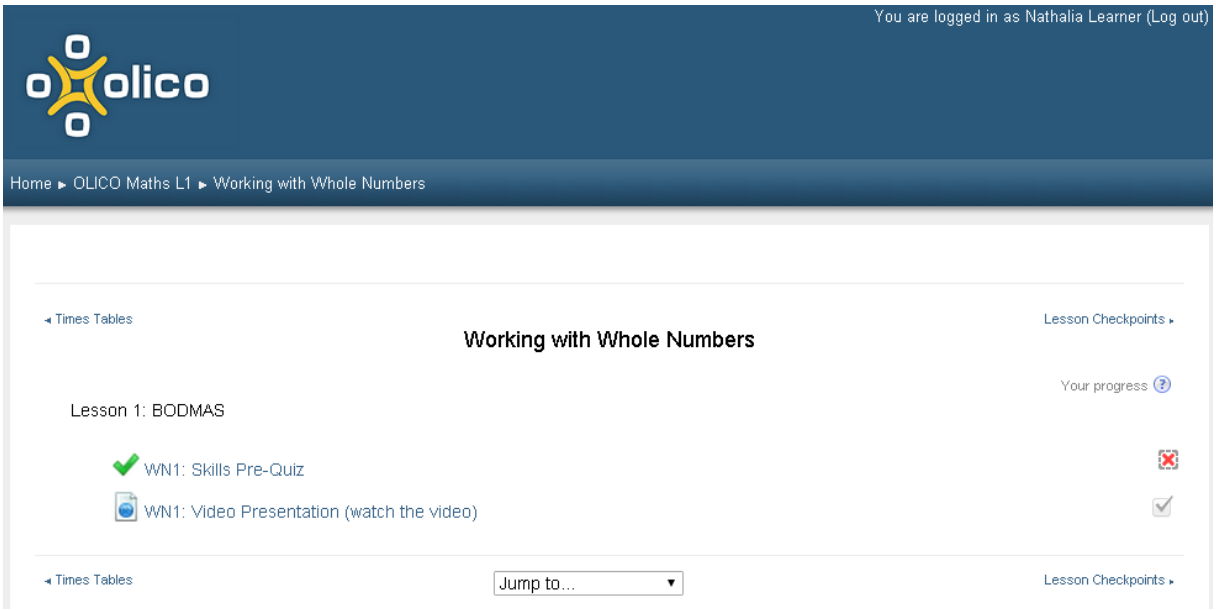


Figure 7: Presentation (1)

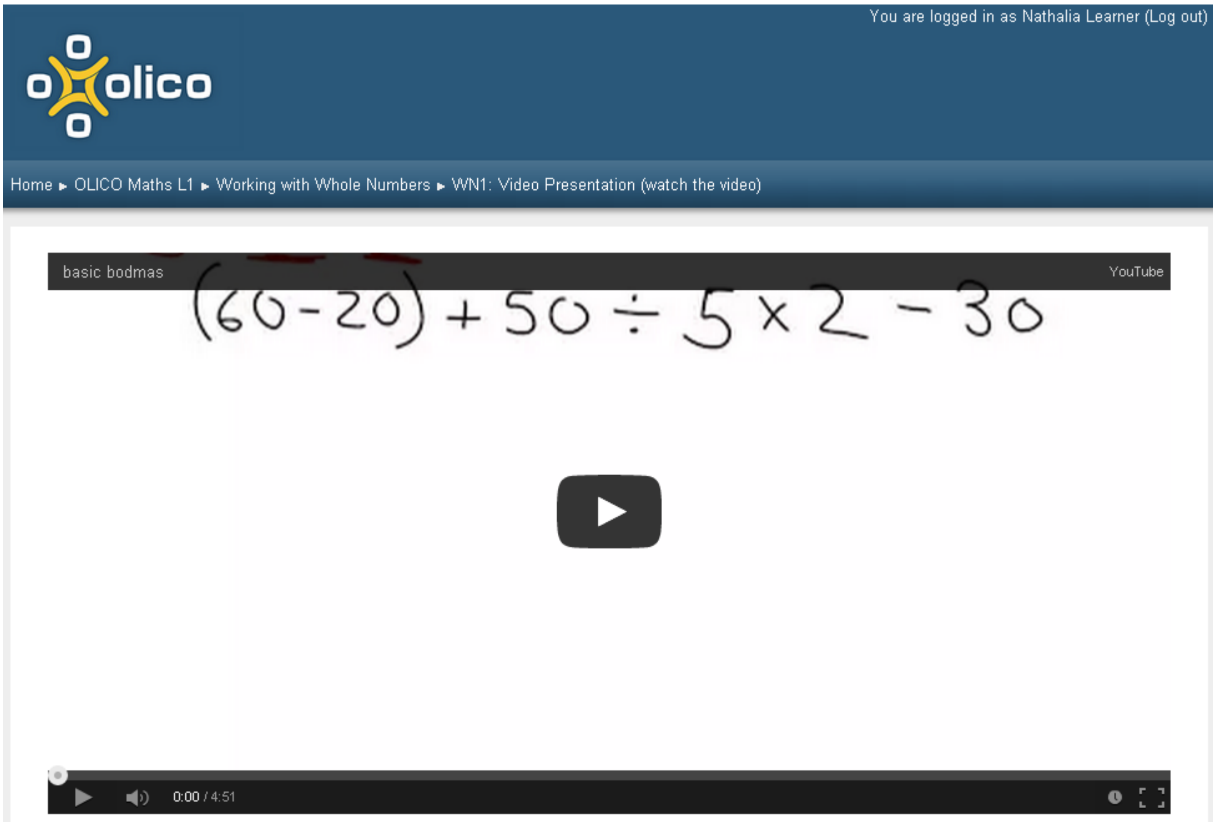


Figure 8: Presentation (2)

The video explains the concept for the lesson and shows the learners several examples. The learners are encouraged to take notes while they watch the video, and there is space in the corresponding homework books for the learners to try some of the examples suggested in the video. Through watching the video, learners should gain an understanding of the lesson topic. The learners are shown how to use the video controls so they may watch the video, or sections thereof, as many times as they need to. Once they have watched the video the next section automatically unlocks.

3. Skills **P**ost-quiz

The skills post-quiz is similar to the skills pre-quiz, although it is typically slightly longer. It appears as illustrated in figs. 9 and 10:

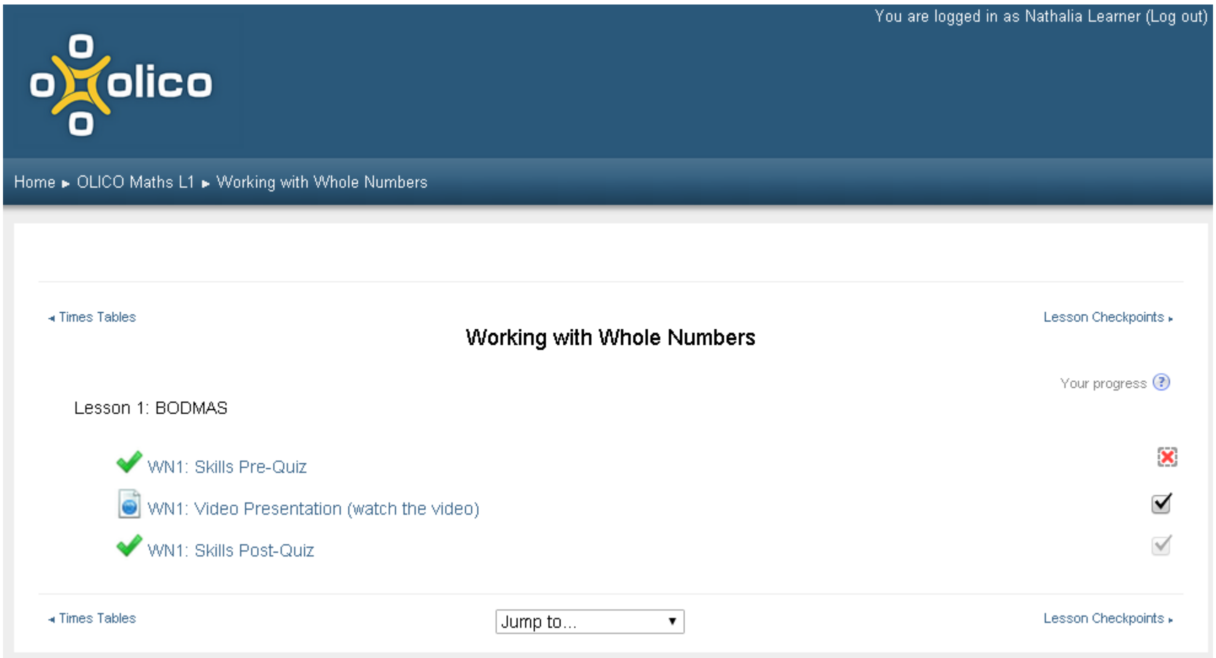


Figure 9: Skills post-quiz (1)

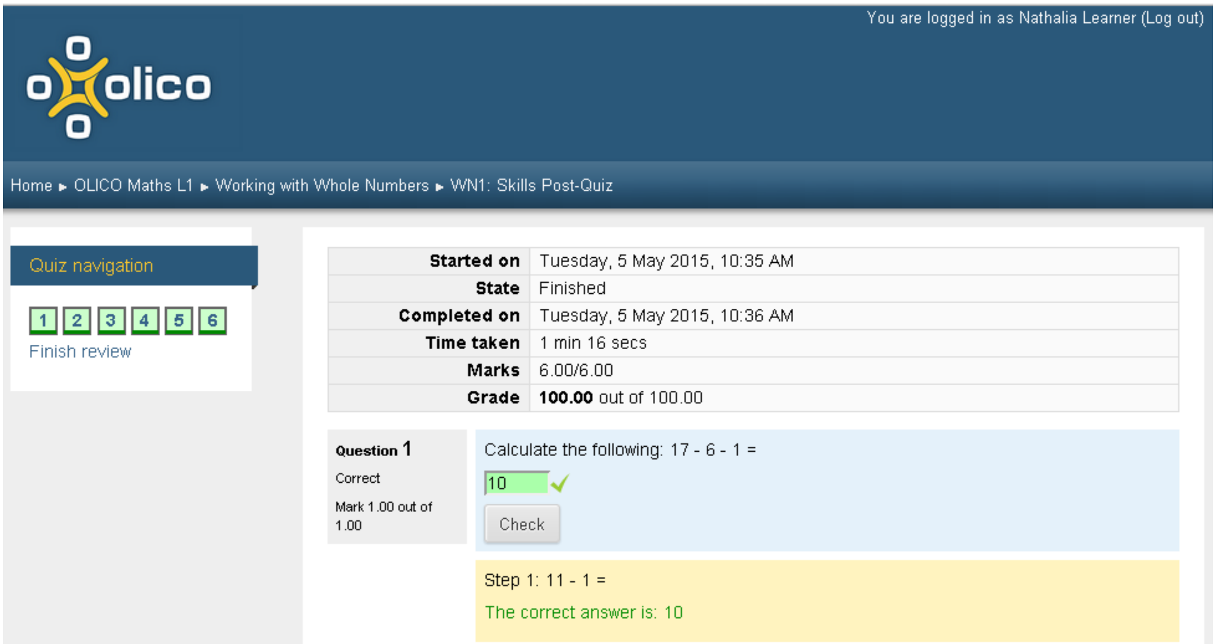


Figure 10: Skills post-quiz (2)

In this section the learners are tested on what was taught in the presentation. In completing the skills post-quiz learners are required to think about what they have learnt in the presentation and apply it in the quiz. This way, learners can see whether they have fully understood the lesson topic and whether they are able to solve problems related to the topic. Learners need to achieve 80% or more to progress on to the next section. If a learner achieves less than 80% they can re-attempt the quiz. Learners can seek assistance from facilitators while they are working on the skills post-quiz. Once a learner achieves 80% or more, indicating they fully understand the work, the next section automatically unlocks.

4. Mixed **P**ractice-quiz

In 2014 it was found that learners would often understand each section individually and achieve quite well in each section, but that this knowledge would not be well retained. The mixed practice-quiz assists learners in revising work they have previously learnt so that previous lessons are not forgotten, and appears as illustrated in figs. 11 and 12:

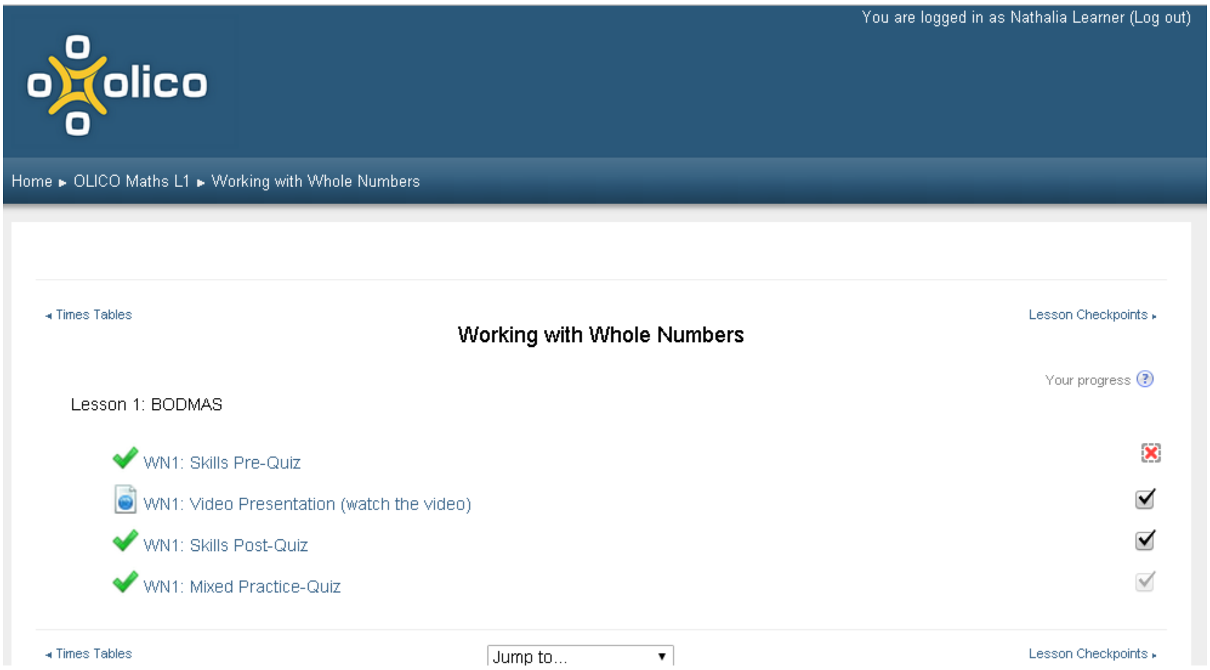


Figure 11: Mixed practice quiz (1)

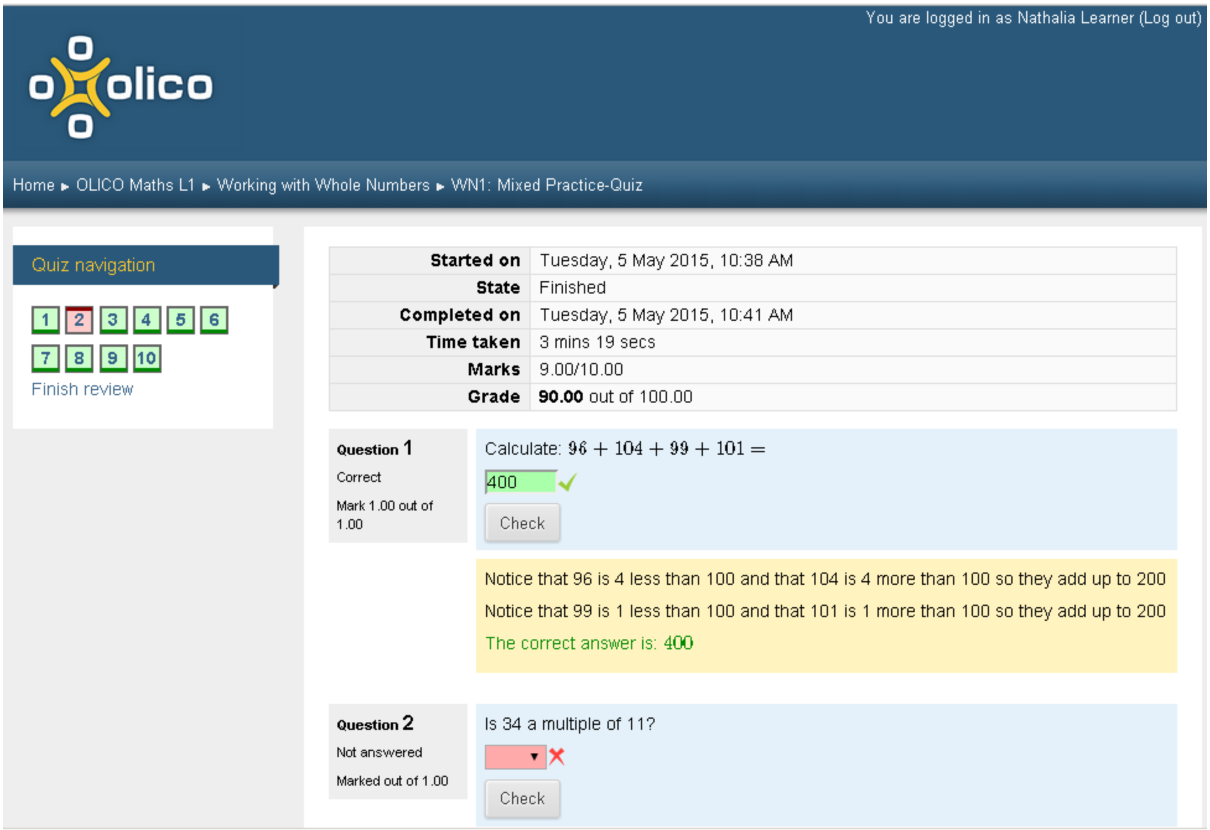


Figure 12: Mixed practice quiz (2)

This quiz consists of questions from a variety of different sections. In doing the mixed practice-quiz learners draw on all their previous knowledge, and need to think about what concepts are at play and what processes to apply in each question. Learners are encouraged to aim for 80% and above in this quiz, however the next lesson will unlock once they achieve at least 60%.

5. **P**ause and review

Learners are encouraged to reflect on what they have learnt. After each afternoon session learners are assigned homework, and after each mathematics section is complete learners write a "Checkpoint test". The checkpoint tests the learners' understanding and retention of all the content learnt in that section. The tests are written on paper, mirroring a typical classroom environment, after which the answers are entered into the mathematics programme where the programme marks it.

These "5 Ps" are repeated for each lesson, with the first four of these being digital, as illustrated in fig. 13 below. The checkpoints are written at the end of a section.

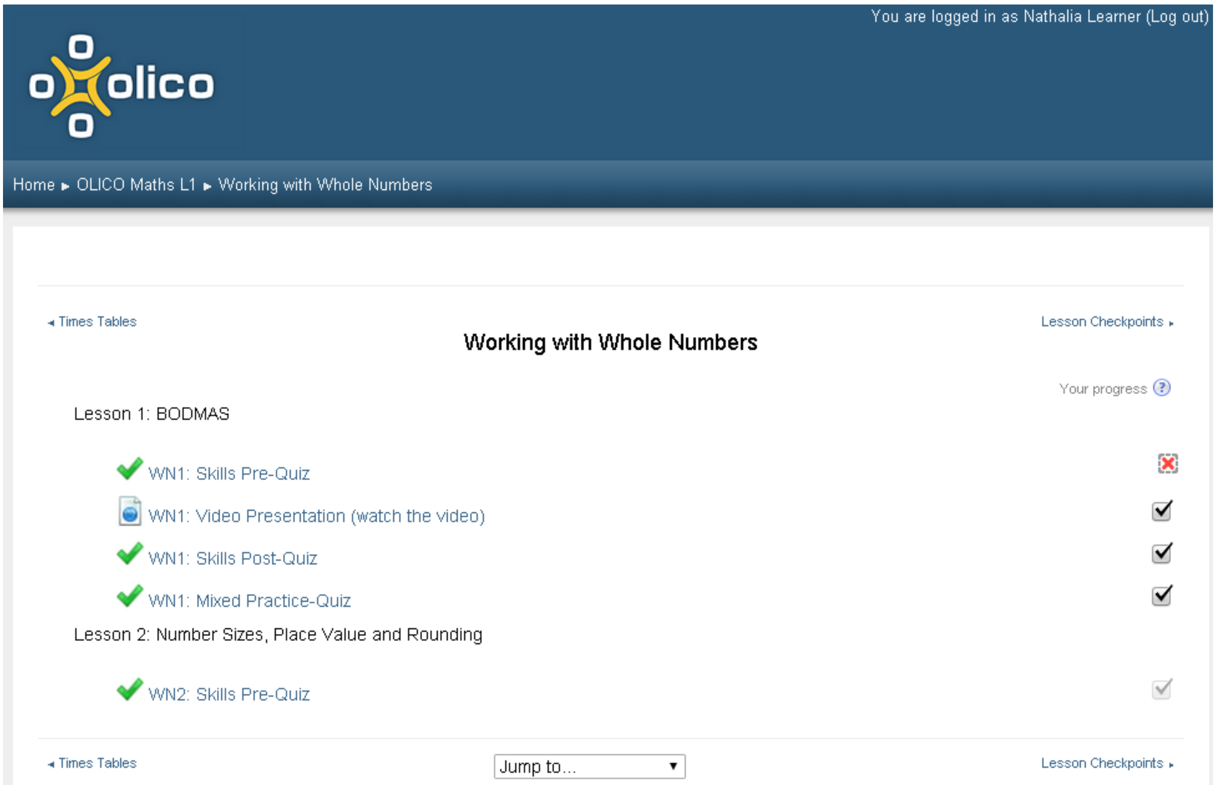


Figure 13: Pause and review

There are several lessons in each section, and learners usually take one to two afternoon sessions to complete a lesson. So, for example, the *Working with whole numbers course* could look something like this for one of the learners:

Monday 4 May 2015: Learner does *Lesson 1: BODMAS* pre-quiz and achieves 50%. Learner watches the presentation. Learner completes the *Lesson 1: BODMAS* post-quiz and achieves 80%. Learner completes *Lesson 1: BODMAS* mixed practice-quiz and achieves 70%, and *Lesson 2: Number sizes, place value and rounding* unlocks.

Wednesday 6 May 2015: Learner does *Lesson 2: Number sizes, place value and rounding* pre-quiz and achieves 80%. Learner skips the presentation and the post-quiz. Learner completes *Lesson 2: Number sizes, place value and rounding* mixed practice-quiz and achieves 80%, and *Lesson 3: More on place value and rounding* unlocks. Learner does *Lesson 3: More on place value and rounding* and achieves 60%.

Monday 11 May 2015: Learner watches the presentation for *Lesson 3: More on place value and rounding* and then writes the post-quiz for which the learner achieves 40%. The learner attempts the post-quiz again and this time achieves 80%. The learner then completes *Lesson 3: More on place value and rounding* mixed practice-quiz and achieves 60%, and *Lesson 4: Column addition* unlocks.

The above example would continue until the learner has completed all seven lessons, or until the set checkpoint day where all learners write the checkpoint, which covers content learnt in all seven lessons. After writing the checkpoint the learners will follow the same processes again for the next topic. This way, learners are able to ascertain what they do and do not understand, they are able to watch videos at their own pace, and they are able to practice the work until they understand it. If a learner is taking a long time to complete a section that they find difficult, they should also attend a catch-up session on a Friday to allow them extra time to catch up to the lesson the rest of the class is on.

1.2.3.3 The bilingual online mathematics course

In an effort to make the OLICO Youth mathematics 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 majority languages spoken by OLICO Youth learners, and for logistical reasons such as staffing and intelligibility to the researcher. The course was bilingual in the following ways:

1. English-isiZulu bilingual hyperlinked glossary

There was a bilingual glossary available as hyperlinks in all of the Fractions pre-quizzes, skills practice quizzes, and mixed practice quizzes. Words were identified as difficult for the learners by the researcher and OLICO Youth team, using qualitative observations and informed speculation. These words were then provided with explanations in English and isiZulu using the *glossary* function on the Moodle. Glossary terms that appeared in the bilingual online mathematics course were blue in colour. This is illustrated with the word "shaded" below:

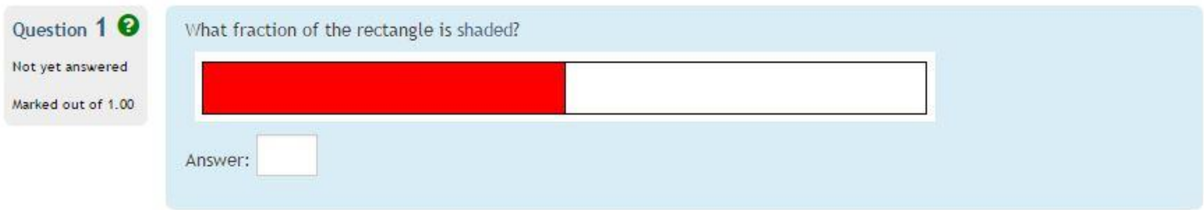


Figure 14: Hyperlinked glossary (1)

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:

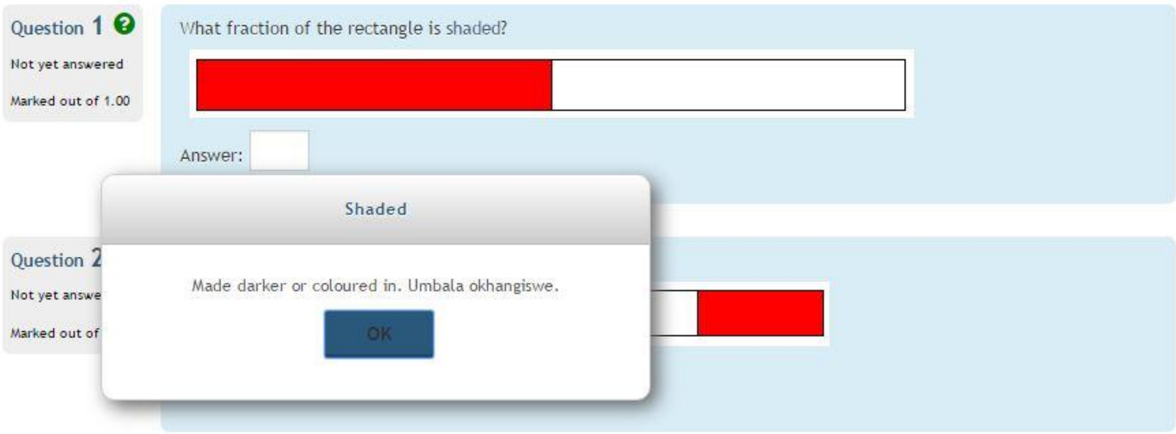


Figure 15: Hyperlinked glossary (2)

This glossary was only made available to learners who enrolled in the bilingual online mathematics course.

2. Homework book English-isiZulu bilingual glossary

The glossary 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:

olico

English-isiZulu Maths glossary

Convert
Change it to something.
Kushinye kulenombolo eyiyo ukwenze iqhezumbulu.

Diagram
A picture that explains something.
Umdwebo o chaza okuthize.

Equivalent
The same as something else.
Okune nani elifinayo kunaleli elighathaniswayo.

Illustrate
Show something using a picture.
Khombisa ngokucacile usebenzise isithombe.

Represent
Show something using words or a picture.
Khombisa umfanikiso omele amagama noma isithombe.

Revise
Look at your work and practice it again.
Buyekeza Umsebenzi wakho.

Shaded
Made darker or coloured in.
Umbala okhangiswe.

Share fairly
So that everyone gets the same amount.
Kuhlukwaniswe ngokulinganayo.

Simplest form
With the easiest or smallest numbers.
Kukhobise ngendlela elula kahulu.

Figure 16: Printed glossary

3. Bilingual videos

The presentations for each section were recorded and presented using a carefully-devised method of codeswitching with isiZulu and English. These will be discussed in further detail later.

1.2.3.4 The team

There were several people involved in the creation, implementation, and review of the bilingual online mathematics course. While they all have significant skills and expertise, they are introduced below with specific reference to the expertise and assistance they provided with this research project.

1. Mathematics coordinator

The mathematics coordinator has a PhD in mathematics education and extensive experience working in mathematics education. She works at OLICO Youth and created the original, English-medium, OLICO Youth online mathematics course. This includes the creation of the programme's curriculum, online questions and videos.

2. Project co-founder

The project co-founder jointly created the OLICO Youth project. He manages the technological elements and the monitoring and evaluation of the OLICO Youth online mathematics course.

3. Bilingual resource creator

One of the OLICO Youth facilitators created the bilingual resources used in this project, namely the English-isiZulu bilingual glossary and videos. He recently graduated with a Politics, Philosophy and Economics degree. His L1 is isiZulu and he studied isiZulu up to Grade 12, as such he has L1 proficiency in spoken and written isiZulu, as well as in English. He also speaks Sesotho as an L2 and is able to understand most of the learners when they speak in their L1s.

4. OLICO Youth online mathematics course facilitators

There are three facilitators for the OLICO Youth online mathematics course, and there are always at least two facilitators in the classroom while the learners work on the mathematics course. The facilitator who created the bilingual resources was introduced in the preceding paragraph. All three facilitators are recent graduates of mathematics-related degrees. While none of these facilitators studied teaching or education, they all have tutoring experience and are highly competent in mathematics.

5. Quality assessor

The mathematics coordinator put me in touch with a PhD candidate from a nearby university whose research areas are language and mathematics. She has isiZulu L1 proficiency and provided feedback on the bilingual videos created by the bilingual resource creator.

6. Winter School volunteers

In the June 2015 school holiday OLICO Youth hosted a week-long Winter School, where learners worked intensely on mathematics, literacy, and creative arts with the assistance of 16 volunteers. The volunteers were all university students or Grade 12 learners who spoke a variety of L1s.

1.2.4 Research problem, research questions and objectives

This research is motivated by the unequal access to quality learning and the resultant lack of socio-economic mobility and agency. This stems from learners learning through a poorly-understood L2 with little to no CALP. The research problem in the context of this research paper is that, despite the extremely low pass rate for mathematics in South Africa, there are very few well-researched multilingual classroom teaching practices, with even fewer of these integrating technology. In an attempt to solve this research problem, the following research questions were asked:

1. How can learners' L1s be viably incorporated in learning?
2. How does the use of translanguaging in the online OLICO Youth mathematics course promote learners' conceptual development?
3. How does the use of translanguaging in the online OLICO Youth mathematics course affect learners' attitudes to learning?

In order to answer these research questions the following objectives were identified:

1. To find out how learners' L1s can be viably incorporated in learning, specifically in the context of the supplementary mathematics programme already in existence at OLICO Youth in Diepsloot, Johannesburg. This objective informs the creation of the design experiment.
2. To find out how the use of online translanguaging in the OLICO Youth mathematics course promoted learners' conceptual development, specifically their development of mathematical concepts. This objective informs the evaluation of the design experiment.
3. To find out how the use of online translanguaging in the OLICO Youth mathematics course affected learners' attitudes to learning, particularly in terms of learners' motivation and their perceived value of their L1s. This objective informs the evaluation of the design experiment.

1.2.5 Conclusion

Taking the South African context into account, it is clear that there is a need for education in South Africa to be cognitively accessible for all. This is indeed a complex task, and the myriad of intricacies extend far beyond the scope of this research. It is furthermore evident that language plays a significant role in making the content taught at school accessible for learners, and also in providing quality post-school and work opportunities which may provide much-needed socio-economic mobility. When looking at the Diepsloot context the highly multilingual nature of the township is notable, and highlights the fact that research in different parts of South Africa, for example multilingual and monolingual and rural and urban contexts, may hold different relevance for each other. The stability and success of OLICO

Youth as a supplementary online mathematics programme gives the perfect opportunity to implement language-based experiments to test theory in practice. This will be explored in greater detail throughout this research project. The following section provides a synopsis of the different chapters of this research project.

1.2 Chapter outline

Chapter 2 discusses the literature that informs this research project. It begins by providing a background of education in South Africa and discussing the socio-cultural and socio-economic factors that influence how education is enacted and received. Thereafter second language acquisition is explained and the implications of learning through a L2 are discussed. The intricacies of learning mathematics are elucidated with a specific focus on the concept of fractions. Different models of teaching and the incorporation of online teaching and learning support are discussed. Codeswitching is then explained, with specific reference to how it is currently used in the South African context. Through this discussion four influencing themes become apparent: socio-political, linguistic, mathematical and personal.

Chapter 3 introduces and discusses design based research (DBR), the methodology used in this research project. It will explain the design of DBR, the method used in conducting this research, the theoretical framework used to create the experiment. The steps taken to collect and analyse the data will be elucidated. The ethics and researcher's biases that were present in this research project will be clarified.

The data that was collected for the purpose of answering the research questions through the implementation of an intervention strategy is presented in Chapter 4. This illustrates the findings of the research in preparation for their analysis.

The data is then analysed in Chapter 5. Each data set is examined, and reasons for the behaviour of the data are sought and explained. These findings are then considered all together and the implications thereof are discussed.

Chapter 6 presents recommendations based on the findings and analysis of the data. These recommendations include recommendations for further research and the possible uses of this research. Thereafter broader conclusions are drawn through considering the research project as a whole.

Chapter 2: Literature Review

2.1. Introduction

> "*It makes immediate sense that learners whose main language is not the LoLT should draw on their main language(s) in the learning process. However, it is often that which makes most sense that is most elusive to critical interrogation.*"
> (Setati and Adler, 2000: 244).

In South Africa a counterintuitive phenomenon exists wherein the vast majority of learners' LoLT is their L2. Despite this, there has been very little academic documentation of how LoLT affects learners' cognition (Blyund and Athanasopoulos, 2014: 438). Titone (1978: 287) notes that there are many areas for which research is needed in order to better develop bilingual, and by extension multilingual, education. The term bilingual refers to the use of two languages, while the term multilingual refers to the use of three or more languages. He suggests that research should seek to find the different benefits of language instruction compared to teaching other subjects through the target language, and that multilingual education should not simply imply the use of different languages as LoLT, but should also emphasise the use of language for cognitive activity (Titone, 1978: 287).

This research aims to investigate how bilingual videos are being used with Grade 7 learners at OLICO Youth, an after-school mathematics support programme in Diepsloot, Johannesburg. This chapter will provide insight into the need for and efficacy of bilingual videos as a teaching tool for Grade 7 mathematics. This will be done by first outlining the state of education in South Africa, with special attention paid to mathematics achievement, literacy levels, and attitudes towards English as LoLT and the use of the L1 in the classroom. This examination will be furthered to look at the socio-cultural and socio-economic implications of language proficiency which transcend one's school years. Thereafter the processes of acquiring a second language will be discussed, focusing on the development of BICS and CALP, and the relationship between home language proficiency and second language acquisition. Thereafter the intricacies of learning through a language other than one's own will be examined, with special attention paid to learning mathematics through English in South Africa. Once this has been examined different models of teaching will be introduced, including models which incorporate computer-based learning, paying attention to the suitability of these models to the South African mathematics education context.

Thereafter codeswitching will be explained, with specific reference to translanguaging and its current and possible uses in South African education. Following the above explanations and discussions it will be concluded that an intervention using translanguaging in a multimedia format is a suitable intervention in the context of South African mathematics education.

A learner's development of multilingualism can be affected by a number of factors, including parents', teachers', and the community's attitudes, and the prestige, function, and prevalence of the languages in the learner's contexts (Baker and Hornberger, 2001: 38). Learners living in urban areas are generally exposed to significantly more English than learners living outside of these areas and as a result have higher English proficiencies (Soudien in Probyn, 2009: 127), although this proficiency is often a far cry from the proficiency needed to successfully cope with English as a LoLT (Heugh, 2013: 224). As a result of the status of English in South Africa, English proficiency is in large part replacing race as the litmus test of social class (Soudien in Probyn, 2009: 127).

It is often made to appear as though multilingual learners in South Africa tend to perform more poorly than their monolingual peers, as has been claimed by some authors (see Reynold and Saer in Setati and Adler, 2000: 244). However, this difference in performance can and should be attributed more to other influential factors than the learners' multilingualism, such as socio-economic status and parents' levels of education, bearing in mind that the majority of multilingual learners in South Africa are children of parents who were not afforded quality education under the apartheid regime. Research has shown that multilingualism can positively influence learners' cognitive development, for example that of Iaco-Worrall, Ben-Zeef, Bialystock, Doyle, and Pearl and Lambert (Setati and Adler, 2000: 245), and the ways in which this is achieved will be discussed further below. As such it is important that learners' academic performance notes their language abilities, but is not viewed separately from their surrounding environments or "the wider social, cultural, and political factors" (Setati, 2002: 13).

Peal and Lambert (in Baker and Hornberger, 2001: 33) suggest the use of socio-economic status, sex, and age as variables that should be matched in order to ensure a more accurate comparison of learners' language abilities. However, this is particularly difficult in South Africa, as a large number of bilingual learners have different socio-economic status to monolinguals. It should be noted that the demographic of learners disadvantaged by the use of a non-mother tongue LoLT is the same demographic as those disadvantaged by Bantu education (Webb, Lafon, and Pare, 2010: 280). Without provisions made for this disadvantage these learners are disadvantaged at school and as a result throughout their lives, and as such the socio-economic segregation of apartheid will be – and is being – perpetuated (Webb, Lafon, and Pare, 2010: 280).

When considering the literature, four clear themes emerged. The overarching theme is the socio-political context of South Africa, which informs the educational landscape and how learners interact with it. Two subsidiary themes are the linguistic and mathematical contexts, which both draw from and contribute to the socio-political context. All three of these themes then inform the personal context, which is considerably more difficult to document, and which focuses on how learners situate themselves within these different contexts. Within these themes are significant sub-themes, which are often in conflict each other. Within the socio-political theme, the utility or prestige of a language often conflicts with the culture and heritage attached to it. Within the linguistic theme, a tension that is very often experienced by teachers and learners is that between using a language necessitated by policy and one necessitated by learners' understandings, or lack thereof. Within the mathematics theme a tension exists between conceptual development and making sure learners understand *what* they are doing, and procedural fluency which ensures learners know *how* to do something. The personal theme does not host tensions as significant as the other themes, but rather exists as a culmination of all these themes. These four themes thus create an analytical framework informed by the literature in this chapter. The themes are illustrated on the following page.

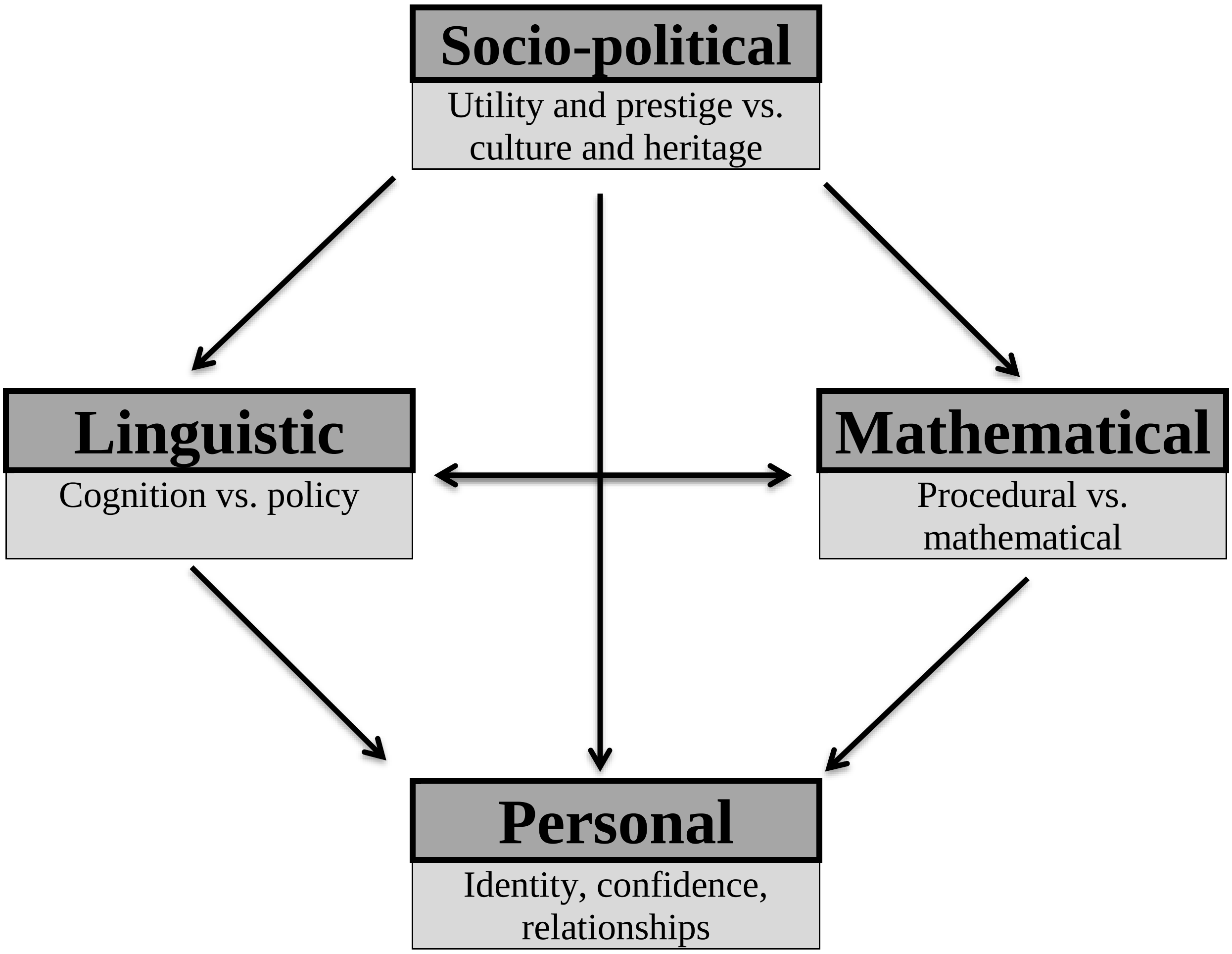


Figure 17: Analytical framework

2.2. Socio-political considerations

To a large extent the socio-political considerations dictate how the linguistic, mathematical and personal themes are played out. The main tension existing within the socio-political sphere is the tension between the utility and prestige of the language, and the heritage or cultural importance of the language. Utility and prestige can be seen, for example, in the universal presence of English and the misconception that African languages are not suitable for academia. The heritage and cultural importance of a language is evident in the number of people who speak the language and often are made to feel that their language is inferior to English.

2.2.1 Education in South Africa

The Bantu Education Act, instituted in 1954, segregated education according to race, and black learners were limited to attend schools in which the LoLT was an African language for the duration of primary school (Webb, Lafon, and Pare, 2010: 278). Because the apartheid regime used education as a means of oppression, education offered to black learners was inferior (Webb, Lafon, and Pare, 2010: 278). The inferiority of Bantu education has therefore been conflated with the use of African languages as LoLT. A resultant argument against the use of African languages as LoLT is that there is insufficient terminology development in African languages, and furthermore that there are insufficient material resources available in African languages, such as textbooks (Probyn, 2009: 127).

The formal language of mathematics in South Africa is most commonly English. While it is arguably possible for other South African languages to be formalised for mathematics, it is vastly underdeveloped and, in many cases, is seen by many as a waste of time (Setati and Adler, 2000: 250). Higher education in South Africa is offered almost exclusively in English or Afrikaans (Setati, 2002: 8), creating yet another reason for parents to choose English for their children over African language proficiency as higher educational institutions do not show sufficient value for African languages.

The Progress in International Reading Literacy Study (PIRLS) of 2006 (Howie et al., 2006) and 2011 (Howie et al., 2006) illustrate a clear problem with South Africa's education system. The 2006 study showed that South African learners performed the poorest out of 40 countries (Howie et al., 2006: 17), and the 2011 study showed that "[t]here was no difference in the overall achievement for South African learners in 2011 compared to 2006" (Howie et al., 2011: xvi). While South Africa does have comparatively poor socio-economic factors influencing this, South Africa's spending on education was average in comparison with that of the other countries (Howie et al., 2006: 3). This leads one to wonder why this spending is relatively so ineffective.

All South African learners are required to pass English (as either a first or second language) as a subject in matric in order to receive their qualification (Setati, 2002: 8). While South Africa has 11 official languages, most policy documents are only available in English (Setati, 2002: 8). The language in education policy (LiEP) advocates use of the L1 as LoLT for the first three years of schooling, with the intention of fostering additive bilingualism (Heugh and Luckett in Probyn, 2009: 127). While South Africa's language policy is argued to be progressive, this does not adequately translate into practice (Setati and Adler, 2000: 252). Additive bilingualism would allow learners to attain good basic understandings of concepts in their L1, which can later be built upon in their L2 (Heugh and Luckett in Probyn, 2009: 127).

Probyn (2009: 128) points out that there are disparities between the LiEP's intentions and its enactment, as the policy is interpreted by each school, with this interpretation influenced by school staff and parents' opinions and the school's resources, and again by the teacher in each classroom according to their understandings of the LiEP, their convictions regarding it, and their linguistic abilities. 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: 280). While codeswitching between English and the school's former LoLT is commonplace in many classrooms, the extent to which this happens depends on the teacher and the school (Ncoko, Osman and Cockroft in Blyund and Athanasopoulos, 2014: 434). By virtue of this fact it is clear that more attention needs to be given to codeswitching by the LiEP (Setati and Adler, 2000: 256). Of particular use would be for the LiEP to guide best practice in codeswitching within a variety of classroom contexts and subjects (Setati and Adler, 2000: 256). In rural schools there is pressure on teachers to use English, as they are the learners' only source of exposure to English (Setati and Adler, 2000: 255). Setati and Adler (2000: 255) also noted that teachers from rural schools opposed the frequent use of codeswitching during classes. In a study by Setati and Adler (2000: 254) it was found that there was a significantly higher presence of codeswitching in urban classrooms than in rural classrooms. This study also found that codeswitching was more prevalent in secondary mathematics classrooms than in primary mathematics classrooms (Setati and Adler, 2000: 254).

Many studies focus on bilingualism which results from migration (e.g. Athanasopoulos et al. in Blyund and Athanasopoulos, 2014: 440) or learning a foreign language (e.g. Kurinski and Sera in Blyund and Athanasopoulos, 2014: 440); however, these contexts are significantly different from the South African context in which the learners' L2 is the dominant language of their country's political economy (Blyund and Athanasopoulos, 2014: 440). The South African political economy is enacted primarily through English, even though the majority of South African learners are not able to acquire the English proficiency required to participate in the school curriculum (Probyn, 2009: 123) and, by extension, the South African political economy.

Currently, teachers are often under pressure to use English whenever possible (Setati and Adler, 2000: 256). Probyn et al. (in Probyn, 2009: 127) suggest that educators who teach in township schools believe that parents send their children to ex-model C schools for their children to learn English, and as such feel compelled to replicate the language model of these schools and use English as LoLT from as early as possible. Many learners' parents were taught under Bantu education, which reserved English as the LoLT in educationally superior contexts while African languages were used to limit access to better education and participation in South Africa's political economy (NEPI in Setati et al., 2002: 131). 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: 131).

Setati et al. (2002: 130) describe the language learning contexts in South Africa as additional language learning and foreign language learning. Additional language learning refers generally to the context of learners in urban schools, where the learners do not speak English as their L1 but have some degree of exposure to the language from their environment, both in print form (for example in advertising) and in spoken form (from other people or television) (Setati et al., 2002: 130). Furthermore, urban schools tend to have a higher degree of multilingualism in general as they have learners from a variety of linguistic backgrounds (Setati et al., 2002: 130). Foreign language learning generally refers to the context of learners in rural schools, as English is typically only used in formal contexts, specifically at school, and there is little exposure (if any) to English in written or spoken form outside of the classroom context (Setati et al., 2002: 130). Learners' linguistic abilities and understandings are moulded outside of the school context by cultural, economic and linguistic factors (Achugar and Carpenter, 2014: 61). This gives learners different experiences of and abilities to learn the types of language needed in the school context (Achugar and Carpenter, 2014: 61). Webb, Lafon, and Pare (2010: 285) suggest that the extremely different contexts of schools should be taken into account by South African language policy. They outline four different types of schools which are likely to have different types of language contexts: rural schools, within which English may be considered a foreign language; township schools, which are generally highly multilingual; lower ex-model C schools and upper ex-model C schools, within which learners are often exposed to English regularly (Webb, Lafon, and Pare, 2010: 285).

2.2.2 Socio-cultural and socio-economic implications of language proficiency

Good proficiency in English, and by implication familiarity with a certain set of Western values, are necessary tools for any person wishing to be successful in an English-dominated world. However, these tools should not be gained at the expense of indigenous languages. For this reason it is important that in the South African context indigenous languages are used and accompanied by an embrace of indigenous cultures and values. In so doing learners will be better able to contextualise what they are learning, as well as feel a sense of recognition of and pride in their identities (Cummins and Swain, 1986: 101). Incorporating indigenous languages and cultures into school lessons may prove to be a difficult task for many South African bilingual teachers, as most of them did not experience such incorporation of their language and culture when they were at school (Benson, 2004: 119). Irrespective of having a model from which to build, simply using the learners' home languages and making references to their cultures promotes the status of the language (Benson, 2004: 119) and the learners' feelings of belonging and self-worth.

Valdés (in Brutt-Griffler and Varghese, 2004: 2) argues that many learners who are at a linguistic disadvantage at school are then restricted in their socioeconomic status. While Valdés argues the case for immigrants in America, this argument rings true for South African learners who are also limited in their class mobility as a result of their LoLT. A notable difference between these two contexts, however, is that the immigrant learners in America are learning in a language of the majority population, while most learners in South Africa are learning in a language that is spoken as L1 by only a minority portion of the South African population.

2.2.3 Models of teaching

In South Africa a common teaching model is that of immersion, where the teacher only uses the learners' L2. While the purpose of immersion is to promote L2 development through the use of the L2 in realistic and everyday contexts (Heller in de Mejía, 2002: 79), it runs the risk of promoting subtractive bilingualism and resultantly many learners tend to rely on memorisation and rote learning (Wababa, 2009: 28). In order to address these issues it is helpful to look at other existing models of teaching.

In order for learners to gain content knowledge without being hindered by an unknown L2, the preview-review model is sometimes used (de Mejía, 2002: 81). In this model the teacher introduces the lesson in the learners' L1 (Ovando and Collier, 1998: 183). During the preview the teacher outlines the lesson's concepts and introduces the new L2 vocabulary that will be used. The target language is then used to present the rest of the lesson, with the teacher and learners expanding on the concepts together (Ovando and Collier, 1998: 183). While the L2 is used it is also beneficial for the teacher to use visual or physical aids (Ovando and Collier, 1998: 183) and supplementary activities (de Mejía, 2002: 81) to assist learners' comprehension and language acquisition. This has proved a successful method for helping learners understand mathematics (González and Lezema in de Mejía, 2002: 81). The lesson is then finished in whichever language is more appropriate, with this generally being dependent on learners' existing language proficiencies (de Mejía, 2002: 81).

Another model sometimes used is the concurrent approach, in which the teacher constantly switches between languages (Ovando and Collier, 1998: 184). This approach requires the teacher to be fluent in both languages being used and their relevant terminology, remaining conscientious of when each language is being used and using equivalent rather than literal translations (Ovando and Collier, 1998: 184). In this approach material is only repeated when deemed necessary, and this is adjusted to suit and improve learners' language levels (Ovando and Collier, 1998: 184). Within this approach learners are encouraged to participate in the language of their preference (Ovando and Collier, 1998: 184). While this approach is likely to greatly assist learners' understanding of content, it is also criticised by linguists and educators as it allows learners to rely solely on their L1 and can result in one language being used more extensively than another (Ovando and Collier, 1998: 184).

In order to ensure certain languages do not unintentionally take prominence, some bilingual models include assigning specific days, times, classes or subjects to different languages (Baker in Benson, 2004: 124). Many bilinguals are not aware of the relative amounts of time they spend using each language (Cummins and Swain, 1986: 107). It is argued that this method is better suited to language acquisition than switching between languages within the same lesson (Dulay and Burt, Legaretta and Swain in Lindholm-Leary, 2001: 68) as learners may pay less attention to what is said in the L2 if they know they can also access this information through the L1 (Cummins and Swain, 1986: 106). Another element of this argument is that it is linguistically easier for teachers (Cummins and Swain, 1986: 107); however, it should be noted that this may not necessarily be the case in the South African context as codeswitching is commonplace and natural for many people.

It would appear that the above models of teaching are strongly dependent on having a fully bilingual teacher. While this is clearly the best scenario, it is also possible for a teacher who cannot speak the learners' L1 to implement these models. This can be done by grouping learners such that stronger learners assist struggling learners by using their L1 according to the above models (Ovando and Collier, 1998: 184).

2.2.4 Blended learning and CALL

We live in a world that is constantly and swiftly evolving, and as such it is imperative that education evolves alongside worldly developments such that education sufficiently prepares learners for the world in which they live (Tucker, 2012: 3). It is no longer relevant for learners to learn by passively observing and listening; they need to be actively involved in their learning and engage with scenarios similar to those they would encounter in real life (Tucker, 2012: 3). In line with this, the digital world has been playing an increasingly important and prominent role in education (Tucker, 2012: 4). This has allowed for blended learning, that is, the integration of technology into the traditional learning sphere, to become increasingly relevant and accessible.

Digital media not only inducts learners into modern means of communication, but also allows for the extra time, explanations and practice needed by the more reserved learners and those who struggle to grasp certain understandings as quickly as their classmates (Tucker, 2012: 4). In order for digital learning to be optimally useful in this regard it is necessary that online curriculum and learning be tailored to different learners' needs (Tucker, 2012: 6). While this is extremely difficult to do when teaching a class of learners in a traditional way, online platforms can more easily be tailored to be learner-centred, follow a learner's own pace, and be customised to each learner's needs. When learners have this degree of control over their learning they are likely to feel empowered and motivated to take control of their own learning (Tucker, 2012: 6).

In a number of blended learning scenarios e-learning labs are created such that the computer is the main reference point for learning, allowing for facilitators who have limited or no training in the subject to monitor the learners (Tucker, 2012: 11). This means that when one teacher could previously only share their knowledge with a limited number of classes and learners, that teacher could now contribute to an online learning platform which could reach far more learners. This is particularly relevant in township and rural schools where learners do not have access to after-school classes as readily as their ex-model C and private school peers, as access to a computer lab and a facilitator with minimal training could open a space for supplementary learning.

Tucker (2012: 12) suggests that blended learning could serve as a teaching aid to complement classwork with relevant and meaningful homework (Tucker, 2012: 12). This is currently being done by several South African schools with the Siyavula Mathematics and Science e-learning programme (which can be found at everythingmaths.co.za). However, as many learners at township and rural schools are several grade levels behind in many subjects it would not be optimally beneficial for learners to continue with grade-level work in an after-school programme. It is for this reason that OLICO Youth has created a programme that mirrors the learning areas in the mathematics curriculum, but provides lessons and practice activities beginning from earlier grade levels to give learners a stronger foundation in their mathematics skills. It is beneficial for information to be presented online and then also discussed in class (Tucker, 2012: 12), which is also being integrated in the after-school sessions at OLICO Youth.

Blended learning can be divided into several different learning models. OLICO Youth makes use of both the Flex and Online Lab models. The Flex model uses the online platform to deliver the majority of the learning content and facilitate most of the work, and further instruction in small groups is sometimes incorporated (Tucker, 2012: 14). The Online Lab model makes use of a school computer lab (or, in the case of OLICO Youth, an independent computer lab) where the content is taught online and the lab is facilitated by para-professionals with limited or no training in the subject (Tucker, 2012: 14).

The efficacy of blended and online learning is naturally influenced by the learners themselves (Tucker, 2012: 16). Self-motivated learners who take responsibility for their learning will naturally gain the most from such learning programmes, as learners who are less mature or motivated often still need teachers to provide the needed motivation (Tucker, 2012: 16). Taking this into account this research has a natural participant selection bias, as the learners still participating in the OLICO Youth programme in July are likely those who are self-motivated and possibly resultantly perform better than their less motivated peers who are naturally excluded from the study.

2.3. Linguistic considerations

2.3.1 Second language acquisition

Second language acquisition is an integral component of South African education, as the vast majority of learners are required to acquire a second language (generally English) in order to access the curriculum beyond the Foundation Phase. As one's ability to succeed in school and, resultantly, to succeed in the workplace, is dependent on one's understanding of the curriculum, the importance of good proficiency in the LoLT cannot be underestimated.

An L2 is most easily acquired in the "critical period" (Gardner-Cloros, 2009: 142) from infancy to puberty wherein an L2 can be fluently acquired (Gardner-Cloros, 2009: 142). This heightened ability to acquire an L2 diminishes as the child grows older (Gardner-Cloros, 2009: 142). While young learners have a stronger propensity for L2 acquisition, this does not mean that it is easy to acquire an L2. Krashen and Long (in Lindholm-Leary, 2001: 66) note that in order to best facilitate young learners' L2 acquisition the language they use should be contextually relevant to the learners; illustrated with clear gestures, and repetitive, slow and simple. It is a fine line that teachers need to navigate to ensure that the language they use is simple enough for learners to keep up with, while also using sufficient target vocabulary and sentence structure that is challenging enough to promote development of new vocabulary and sentence structure (Krashen and Long in Lindholm-Leary, 2001: 66).

The brain's working memory generally stores around seven verbal items at a time, making it necessary for one to read fluently in order to retain and understand the information being read (Abadzi, 2008: 584). Beginner and poor readers read word-by-word, making it difficult to retain and understand longer sentences and paragraphs (Wales, 1990: 177). If a learner is decoding the language word by word this interferes with their ability to retain the content of the words they just read, also making it difficult to retain and understand longer sentences and paragraphs (Wales, 1990: 177). This means that even if a learner is able to decode a word perfectly, that is, even if the learner can figure out the pronunciation and meaning of a word, the time taken to do so remains a contributing factor to their understanding of sentences (Verhoeven, 1990: 37). If a learner is overly-reliant on bottom-up processes, that is, if a learner reads by decoding one piece at a time (for example word-by-word, or letter-by-letter) and does not make assumptions from the context, then it is likely that the reader will lose the meaning of the text as they are retaining too many discrete pieces of information in their working memory (Abadzi, 2008: 584). The same logic applies when learners are listening to a teacher speaking; if learners are overly-reliant on bottom-up processes to decode teachers' speech, or if they simply take too long to decode, it is likely that their retention and understanding of the teachers' speech will be limited (Verhoeven, 1990: 37). In order for learners to understand the content being read or taught it is ideal for the language used to be a language in which the learners are fluent enough to follow and retain new information. If this is not possible it is important for learners to have enhanced metacognition, that is, an awareness of what they understand and how they understand it (Brown in Fitzgerald, 1995: 150) in order to improve their processing skills.

The South African LiEP alludes to fostering additive bilingualism, that is, the learning of a L2 while maintaining the L1. 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: 40). 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: 8). However, this shift occurs too early, creating a language learning environment of subtractive bilingualism, wherein the L2 is learnt at the expense of the L1 and gradually replaces it (Heugh in Howie et al., 2006: 9). 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: 40). This insufficient language proficiency then also limits learners' access to what is taught in all subjects taught in their L2, making learners struggle through school (Wababa 2009: 9).

It is therefore problematic that the South African education system formally assesses understanding through English, despite the fact that CALP takes more than the three years of Foundation Phase to develop. Many teachers are particularly aware of this, and as such use codeswitching in an attempt to bridge the gap. However, in many cases where codeswitching is used as an ad-hoc solution it is likely that codeswitching will equip learners with conceptual understanding, but not the language English proficiency needed to express this understanding. For learners to be able to express their knowledge in English they also need sufficient exposure to good quality English, as well as opportunities to use it themselves.

Supporting the premise of additive bilingualism are Cummins' Common Underlying Proficiency (CUP) model and Development Interdependence Hypothesis. The CUP 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: 151). 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: 26). It is, however, also important to note that certain concepts may differ when they are reinterpreted from one language to another (Wales, 1990: 175). 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 transferral of concepts across languages.

Furthermore, it is not sufficient to simply have good L1 skills when learning an L2. The Development Interdependence Hypothesis argues that the development of an L2 is largely dependent on exposure to and use of the L2 in contexts beyond the classroom (Cummins in Wababa, 2009: 20). This is evidenced by a study by Anthony and Setati (2007: 217) where it was found that learners' frequency of English use directly correlated with their Grade 12 mathematics examinations, where learners who used English less frequently outside the classroom than their peers achieved lower grades than their peers who used more English outside the classroom. Unfortunately, many South African learners do not have many opportunities to use or engage with written or spoken English outside of the classroom, putting many learners at a very difficult disadvantage.

2.3.2 Learning a second language

> *"Continued difficulties with language over a prolonged period of time are likely to mean that a bilingual child's interaction with an increasingly symbolic environment will not optimally promote his cognitive and academic progress."*
> (Baker and Hornberger, 2001: 41)

Vygotskian theory (in Baker and Hornberger, 2001: 45) states that thought cannot exist independent of language, as thought depends on internalised language for its existence. Premising that this is true, it is reasonable to conclude that thought is limited if language is limited. The extent to which one's language is developed plays an influential role on one's mathematics achievement (Secada in Setati and Adler, 2000: 245). It was found that in cases of subtractive bilingualism, where learners were orally proficient in English but had not received instruction in their L1, learners' mathematics achievement was poorer (Secada in Setati and Adler, 2000: 245).

Additive bilingualism has been reported to have been most successful in communities where the L2 is a language of social relevance, while the L1 is a dominant language or is prestigious (Lambert in Baker and Hornberger, 2001: 39). In situations where the L2 is the more dominant or prestigious language subtractive bilingualism is more likely to occur, where the L1 is eventually replaced by the L2 (Lambert in Baker and Hornberger, 2001: 39). The term subtractive bilingualism thus stemmed from the observation that a bilingual person's competence in their L1 is lessened as their competence in their L2 increases (Lambert in Baker and Hornberger, 2001: 39). In such situations it is common for the bilingual to not attain full competence in either their L1 or L2 (Baker and Hornberger, 2001: 39). Semilingualism (a term coined by Hansegard and Skutnabb-Kangas in 1968 and 1975 respectively, in Baker and Hornberger, 2001: 40) refers to subtractive bilingualism which arises when a person has received exposure to more than one language since childhood, but has not fully developed either language as they have not received adequate training in these languages (Baker and Hornberger, 2001: 40).

While bilingualism is able to support cognitive growth, it is unlikely to do so if a person is only semilingual (Baker and Hornberger, 2001: 41). If a learner does not have the linguistic resources to comprehend elements of the school curriculum, that learner's interaction with the curriculum and subsequent learning is limited, and the learner may also have difficulty expressing their understandings or lack thereof (Baker and Hornberger, 2001:

42). A further problem arising from this is a lack of motivation and curiosity to learn (Baker and Hornberger, 2001: 42), which even further limits potential for cognitive growth. Language difficulties that limit learners from accessing school content are not limited to lack of vocabulary or syntactic knowledge; rather, learners often find the language generally unfamiliar and struggle to make links between their existing knowledge of the language (Macnamara in Baker and Hornberger, 2001: 43). Linguistic competence increases in importance as learners move from concrete to abstract operations and ways of thinking (Baker and Hornberger, 2001: 42). From Grades 1 to 6, operations are primarily context-embedded and concrete (Baker and Hornberger, 2001: 42), meaning that learners with poor language competence are able to deduce meaning from the context. However, as content becomes more context-reduced learners are less able to deduce meaning from the context and larger emphasis is placed on deducing abstract meaning, which is a lot more dependent on linguistic competence (Baker and Hornberger, 2001: 43). This means that semilingual bilingual learners are likely to fall more and more behind, and that the consequences of semilingualism will become increasingly apparent in the higher grades.

Multilingual infants are likely to have more difficulties than monolingual infants during the initial stages of language development, as they cannot simply link a word to a concept: “Instead of linking labels and syntactic programmes directly to concepts in the network, the infant’s linkages must be conditional on extraneous factors” (Titone, 1978: 289). However, once multilingual children have mastered this they should attain a better understanding than monolingual children of how concepts link to words and the fluid nature thereof (Titone, 1978: 289). Exposure to different types of words (Pan, Rowe, Singer and Snow, 2005 and Aukrust, 2007; Bowers and Vasilyeva, 2011; Dickinson, 2001; Han, Roskos, Christie, Mandzuk, and Vukelich, 2005 in Aukrust and Rydland, 2011: 198) and frequently hearing new words play a large role in developing the size of both monolingual (Hart and Risley in Aukrust and Rydland, 2011: 198) and multilingual learners’ vocabularies (Vermeer in Aukrust and Rydland, 2011: 198). Exposure to more uncommon words tends to yield a larger vocabulary than the quantity of exposure to speech (Weizman and Snow in Aukrust and Rydland, 2011: 199). While relatively few studies have been done to explore the effects of exposure to speech on L2 vocabulary (Aukrust and Rydland, 2011: 199), Weizman and Snow’s study suggests the possibility that exposure to multilingual speech – and thus exposure to a vast array of words – may have a positive effect on learners’ vocabulary size.

When children learn new words, they deduct meaning from the context in which they encounter the word (Aukrust and Rydland, 2011: 199), and even more so for second language learners (Carlo et al. in Aukrust and Rydland, 2011: 199). Learners' vocabularies play a larger role when reading in an L2 (Droop and Verhoeven and Lervag and Aukrust in Aukrust and Rydland, 2011: 206), as they are less able to deduce meaning from context than are learners reading in their L1. The classroom environment also does not generally cater to individual learners' needs, and as such context may not be elucidated to the extent needed for some learners to extract meaning (Aukrust and Rydland, 2011: 199). It is possible in these cases for teachers to aid learners by explaining the words, and it has been found that learners' vocabularies were greater in cases where teachers had isolated words and provided explanations when compared to learners who had not received such explanations (Penno, Wilkinson, and Moore in Aukrust and Rydland, 2011: 199). In cases where multilingual learners' exposure to their second language is largely restricted to the language they encounter at school, these learners are unlikely to develop a rich vocabulary as the meanings of the words they encounter are limited to the restricted context in which they encounter them (Aukrust and Rydland, 2011: 205).

For the variety of school subjects learners need to learn the associated discourse: the vocabulary, forms and registers (Setati et al., 2002: 135). Learners also need to learn how to transform their informal spoken language, that is, the language they would use outside of academic environments, to the formal spoken and written language expected for academic contexts (Setati et al., 2002: 135). Most learners in South Africa need to not only learn the formal spoken and written language, but many learners do not have informal competence in the LoLT, or formal language in their L1s.

Cognitive processes and social development are facilitated through language (Webb, Lafon, and Pare, 2010: 284). As such, the higher one's language competence, the better one's ability is to access and understand information (Webb, Lafon, and Pare, 2010: 284). This is especially true in the education context, within which learners' linguistic abilities directly affect their ability to grapple with the content and concepts they encounter. In situations such as these, learners need the necessary vocabulary and grammatical understanding, as well as knowledge of text genres, the ability to discuss and understand abstract concepts, the socially acceptable ways in which to communicate, and knowledge of how to integrate different knowledge bases (Webb, Lafon, and Pare, 2010: 284). To master all of the aforementioned linguistic elements learners need well-developed CALP (Webb, Lafon, and Pare, 2010: 284). CALP becomes even more important in the development of disciplinary literacy, as from high school onwards academic language develops and specialises for different subjects and contexts (Achugar and Carpenter, 2014: 61).

Using multiple languages in mathematics does not simply mean creating singular meanings with different words. On the contrary, words hold different meanings and connotations in different languages, and as such the learners are making distinct meanings within each language's discourse (Moschkovich, 1999: 28).

Talking is an integral part of the learning process. As such, learners need a degree of fluency in the language(s) in which they are communicating (Setati and Adler, 2000: 246) so as to not be hindered in their conceptual thinking by linguistic incompetencies. When considering research done with Spanish L1 learners in English-LoLT mathematics classrooms, Moschkovich (1999: 27) notes that much of the research uses learners' ability to solve word problems rather than examining learners' competencies in mathematical conversations and their ability to create mathematical meaning (Moschkovich, 1999: 27). Moschkovich (1999: 29) notes that it is insufficient to focus only on register, without sufficient focus on discourse. Secada (in Setati, 2002: 12) has shown that oral proficiency in the LoLT when not accompanied by any learning through the L1 has resulted in poorer mathematics achievement. Similar findings in the South African context were also made by Rakgokong (in Setati, 2002: 12), who posited that learners who only learnt in a second-language LoLT experienced difficulties with problem solving as learners were not fluent in the language needed for procedural and conceptual discourse.

In a study done by Setati and Adler (2000: 263), in which they examined teachers' roles in learners' language development in "urban multilingual classrooms" (Setati and Adler, 2000: 264), a teacher was observed who pointed out the important mathematics language to her learners. As a result of this, it was observed that when learners were discussing mathematics they were able to codeswitch between informal Setswana and formal mathematical English (Setati and Adler, 2000: 263). Setati and Adler (2000: 264) describe this teacher's learners as "relatively fluent in English", but note that many learners were not able to speak about mathematics without using their L1 to an extent. In light of this, Setati and Adler (2000: 264) suggest that if the teacher did not allow the learners to use their L1, the conversations would be exclusively formal and as such restricted in terms of learners' explorations and discussions of the topics (Setati and Adler, 2000: 264). In cases such as these, codeswitching allows for fluidity between formal and informal language discourses (Setati and Adler, 2000: 264).

Language facilitates thought, and as such learners should be given opportunities to explore thoughts in the language(s) in which they are most comfortable; this is known as "exploratory talk" (Setati et al., 2002: 130). Most teachers guide their learners toward being able to write formal mathematical language (Setati and Adler in Setati, 2002: 10). In addition to this, learners need to be able to understand, express themselves, and read and write in the target language and register(s), and this is known as "discourse-specific talk" (Setati et al., 2002: 130). While mathematics has 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: 9). 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 their meanings are very specific in mathematical English (Setati, 2002: 10). Setati (2002: 9) suggests that in South African mathematics classrooms there are many types of language that should be encountered: conversational English and mathematical English, "formal and informal mathematics language", conversations about procedure and conversations about concepts, and leaners' L1s and the LoLT.

The ways in which a language describes aspects of a reality is believed to have an effect on how the speaker perceives that reality (Blyund and Athanasopoulos, 2014: 431). With the presumption that this is the case, one may then question how multilingual people think. Blyund and Athanasopoulos (2014: 431) suggest that the extent to which a person's multilingualism affects their cognitive behaviour is dependent on the person's proficiency in, history with, and uses of their languages. Conceptual transfer refers to instances where a person's perceptions shaped by one language transfer to their use of another language (Jarvis, 2011 in Blyund and Athanasopoulos, 2014: 438).

The act of reading consists of decoding (that is, mapping the writing to sounds and putting those sounds together to create words) and comprehension (understanding what those words mean (Stothard and Hulme in Helwig et al., 1999: 114). Reading fluency is attained when a reader is able to decode without having to expend mental energy on doing so, thus allowing mental energy to be expended on comprehension (LaBerge and Samuels in Helwig et al., 1999: 114). As a result, readers who are not fluent decoders are likely to struggle with comprehension more than fluent readers do (Marston and Yuill and Oakhill in Helwig et al., 1999: 114). In mathematics, problems that are strictly computational in nature do not require much language decoding competence in order for the learner to make sense of it, while word problems do require fluent decoding skills (Helwig et al., 1999: 114).

2.3.3 Learning through a second language

It is often noted that many South African learners are disadvantaged by socio-economic status or psychological learning impairments; however, the disadvantage created by the LoLT is often left on the backburner. Learners who are not fluent in the LoLT are at an immediate disadvantage, and in South Africa this is the case for most learners from Grade 4 onwards. In spite of this, learners are expected to learn through their L2 in a curriculum designed for learners proficient in the LoLT. This results in many learners for whom the LoLT is their L2 only acquiring conceptual knowledge later than their peers for whom the LoLT is their L1, and in some cases these learners simply do not acquire the conceptual knowledge at all (Wababa, 2009: 25).

When speaking about language proficiency it is necessary to differentiate between BICS and CALP. 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: 10), and up to ten years or even longer to attain L1-level CALP (Cummins, Collier, Thomas and Collier in Ovando and Collier, 1998: 182). Clearly this would put any L2 speaker of the LoLT at an immediate academic disadvantage that would take 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: 26). Cummins and Swain (1986: 153) conceptualise BICS and CALP as being situated on two continua. One continuum ranges from context-embedded to context-reduced, representing how much one would need to rely on the context to make sense of the language used (Cummins and Swain, 1986: 153). Context-embedded language is generally easier to understand as it incorporates or makes reference to the immediate world, while context-reduced is more difficult to understand as it can exist without making any reference to the immediate world (Cummins and Swain, 1986: 153). The second continuum ranges from cognitively demanding to cognitively undemanding (Cummins and Swain, 1986: 153). This measures how much cognitive capacity is needed to understand the language, or how many separate pieces of information need to be understood and synthesised (Cummins and Swain, 1986: 153). When learners are still learning a language many processes are not yet automated, and this places stress on the brain as many processes must take place simultaneously in order for the brain to synthesise the new information. This would be represented at the bottom of the cognitive capacity continuum, representing cognitively demanding language synthesis (Cummins and Swain, 1986: 153). Language fluency and automaticity would be represented at the top of this continuum, as less strain is placed on the brain in order for understanding to occur (Cummins and Swain, 1986: 153).

It would appear sensible to use context-embedded language when teaching learners who are still learning the LoLT; however, this is not necessarily the case. While a context-reduced style of teaching dominates in South African education, this does not develop learners' understanding that concepts can be related to other contexts and are not permanently embedded in the context in which they are learnt (Awoni in Wababa, 2009: 12). However, context-embedded language is still important to use during language development as it allows learners to match the unknown (new language) with the known (their context) (Cummins and Swain, 1986: 158). When learners experience poor language acquisition it is often the result of insufficient context-embedded language in the initial language learning phases (Cummins and Swain, 1986: 158). This is commonplace in South Africa and elsewhere when learners are taught English with limited, if any, reference to the learners' immediate worlds, including their language, culture, and experiences (Cummins and Swain, 1986: 158).

In a study by Faltis and Hudelson (1998: 47) it was found that English L2 speakers achieved lower test scores than their English L1 peers in English Second Language (ESL) and transitional school programmes, but English L2 learners who had been in bilingual schooling programmes for four to seven years achieved scores on par with their English L1 peers. Given the number of years needed to attain CALP in an L2 it is beneficial to include the L2 in the language and content subjects' curricula from the early grades in order to improve learners' grammar, vocabulary and CALP. However by the same token it is important to recognise that learners will not fully be able to grapple with cognitively demanding subject matter in their L2 until they have developed CALP. Furthermore, much of what learners learn in their L1 can be transferred to their L2 (Cummins in Ovando and Collier, 1998: 182). As such the use of the L1 becomes imperative if learners are to fully grasp subject matter of content subjects, and this can later be transferred to their L2 once they have attained the necessary CALP for this (Cummins in Ovando and Collier, 1998: 182).

There is much contention around using borrowed words. As many academic terms do not currently exist in most South African languages it is easiest to borrow the English words. However, Wababa (2009: 38) argues that this is an ineffective tool as it does not promote learners' conceptual development.

2.3.4 Codeswitching

Setati and Adler (2000: 264) argue that codeswitching in the classroom is “inevitably complex”. Codeswitching may occur for a number of reasons, namely:

- To emphasise a point,
- Because a word is not yet known in both languages,
- For ease and efficacy of expression,
- For repetition to clarify,
- To express group identity and status or to be accepted by a group,
- To quote someone,
- To interject in a conversation, or
- To exclude someone from an episode of conversation

(Baker in Setati, 2002: 14)

Grosjean (in Setati, 2002: 14) argues that most multilingual people codeswitch when they cannot think of the apt expression or word in the language they are using, or because it does not exist in the language they were using. This is evidenced in South African mathematics classrooms, where most mathematical terms commonly known to the learners are in English (Setati, 2002: 14). Even if the mathematical term is known to the learner, it is likely that they will still use the English term because, as argued by Setati (2002: 14), most South African schoolchildren learn mathematics through the medium of English. Conversely, Poplack (in Setati, 2002: 13) posits that codeswitching is not a problem that occurs due to language incompetencies, but rather an ability that arises from proficiency in multiple languages.

Codeswitching has been, and to a large extent still is, viewed as an inferior language practice in South Africa (Setati, 2002: 13). However, codeswitching in South African classrooms allows learners to form understandings of new content and concepts while their language proficiency in the LoLT is still developing (Setati et al., 2002: 134). For example, in Setati and Adler’s (2000: 261) study it was observed that when one teacher introduced the anagram *SPCA* in a word problem, she asked the learners what it meant. One learner asked if he could say it in Setswana, which the teacher allowed, and this created a space in which the learner could interact with the teacher in an informal conversation about the context which would then enable his understanding of the concept. In a study by Moschkovich (1999: 11) a Grade 3 Mathematics teacher was observed focusing on learners’ understanding of content, and not on their correct use of language. In doing so, the teacher reiterated the learners’ utterances to formulate them into mathematical registers and used explanation, gesticulation and tactile stimuli to ensure learners' understanding (Moschkovich, 1999: 11). Codeswitching also creates metalinguistic awareness (Coste, Coste and Pasquier and Gojo and Serra in Moore, 2002: 279). Codeswitching also allows learners to create fluid links between items and the words used for them, thus making them able to adapt to and make use of different descriptions of concepts (Coste, Coste and Pasquier and Gojo and Serra in Moore, 2002: 279). The importance of this is illustrated in Arthur's (in Setati, 2002: 14) study where it was found that learners' ability to make meaning through exploratory talk was extremely limited as a result of learners having to use English for every aspect of learning, and not being permitted to use their L1 for exploratory talk.

While the use of codeswitching in the classroom is important both pedagogically and politically, it is also a complex matter (Setati and Adler, 2000: 243). While the LiEP does encourage codeswitching in the classroom (Setati, 2002: 13), very little guidance is given on how to do so. Even though the vast majority of South Africa's schoolteachers are bi- or multilingual, most teachers are unable to teach through the medium of African languages (Setati et al., 2002: 132). The Department of Education (in Setati et al., 2002: 132) has stated that it would be highly beneficial for teachers to be able to facilitate language learning in all school subjects; however, this is hindered by teachers' inability to teach through their learners' L1. A further complication of the linguistic landscape in South African schools is that the L1s spoken by the learners often differ from the standardised "written" form of the language (Webb, Lafon, and Pare, 2010: 282), making it seem less fit for academia and also more difficult for teachers to model correct language use. Setati and Adler (2000: 255) found that the teachers in their study experienced the "dilemma of codeswitching" (Adler in Setati and 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 and Adler, 2000: 255). This dilemma is extended to the teacher's encouragement and allowance for their learners to use codeswitching (Setati et al., 2002: 140).

When the term *translanguaging* was first used by Williams in 2002 (Hibbert and van der Walt, 2014: 5) it was used to describe acquiring information in one language and articulating or expanding on this information in another language (Hibbert and van der Walt, 2014: 5). This term has since evolved to encompass multiple multilingual practices, notably including varieties of codeswitching (Hibbert and van der Walt, 2014: 5). García argues that "Translanguaging goes beyond code-switching, but incorporates it" (in Creese and

Blackledge, 2010a: 549). This is in response to the common idea that codeswitching arises from language deficiencies (see Grosjean in Setati, 2002: 14). García (in Creese and Blackledge, 2010a: 549) describes translanguaging as the deliberate use of two or more languages to create and control meaning and to form understandings, going beyond traditional conceptions of language boundaries. Beyond creating surface-level meaning, translanguaging also allows people to create meanings around their identities, as has been found by Rampton (in Creese and Blackledge, 2010a: 555) who found that adolescents created unique linguistic practices as a way of creating and managing their identities. As such, translanguaging is best understood within a social constructivist framework, as this allows for language to be viewed in context, without restricting it to predefined categories (Creese and Blackledge, 2010a: 555).

Traditionally languages have been kept separate within bilingual education programmes (Creese and Blackledge, 2010b: 104); however, Makoni and Mashiri (in Creese and Blackledge, 2010b: 106) argue that language policies should not try to separate languages and create artificial boundaries. García (in Creese and Blackledge, 2010a: 570) argues that language in education should incorporate the translanguaging practices already existing amongst learners in different contexts, allowing learners to create their own meanings, understandings and identities. Setati and Adler (2000: 265) suggest that more research needs to be done on the different codeswitching contexts in South Africa, in order to utilise multilingualism and codeswitching as a resource in language in education policy.

The use of codeswitching allows learners to quickly and easily access content and concepts (Butzkamm in Ncoko et al., 2000: 230). Wababa (2009: 19) argues that this can be done most effectively by using learners' L1 to describe concepts. In doing so one must be cognisant of the use of borrowed words, as when borrowed words are used and not explained they limit the accessibility of the content being explained in the L1 (Wababa, 2009: 35). In certain cases, however, the borrowed word may have been used so often that it has been assimilated into the L1, or such that it is situated somewhere on a continuum ranging from directly borrowed from the L2 to fully lexicalised in the L1 (Myers-Scotton, 1992: 21). There is a common misconception that African languages have not and cannot be developed for use in academia (Bamgbose in Wababa, 2009: 12). However, simply because a language does not have a lexical item to represent a certain concept or object does not mean that its speakers do not or cannot know understand the concept or know about the object (O'Neil in Wababa, 2009: 12). In order for academic terminology to be developed in African languages the languages first need to be recognised as suitable for academia, and secondly they need to be used in academia. In the interim teachers should be able to create their own terminology or borrow from English and provide comprehensive explanations of the words and concepts such that these borrowed words can be lexicalised in African languages.

In South Africa there appears to be a mixture of codeswitching and translanguaging in classroom settings. Teachers in South Africa often use codeswitching when they are not fully fluent in the LoLT (Ferguson in Wababa, 2009: 12). However, this is done unsystematically without clear guidelines or planning (Benson, 2004: 117). In such situations it is likely that the learners lose motivation to learn the target language as the content is equally available in their L1 (Swain in Mejía, 2002: 77). Conversely, Arthur (1996: 17) found that codeswitching was being used effectively in schools in Botswana, where it had functions such as highlighting the importance of a certain aspect of a lesson. Supporting this, Merritt et al. (1992: 109) note that the most important factor in successfully using codeswitching in the classroom is consistency, as this gives learners a predictable format to pay heed to.

While many learners use translanguaging informally, the demand for English from Grade 4 onwards results in many semilingual learners who do not possess adequate linguistic resources in any of their languages. It is therefore worthwhile examining what classroom practices could facilitate learner use of translanguaging, that is, mastered use of more than one language. Titone (1978: 286) argues that bilingual education can only truly exist if both languages are fully utilised as languages of instructions and transmitters of culture. Moschkovich (in Setati and Adler, 2000: 248) posits that teachers' "revoicing" of learners' informal language can have significant positive effects on learners' acquisition of formal mathematics language. Setati et al. (2002: 145) argue for an exploration of how learners could be guided from informal and exploratory talk in their L1 to the formal use of English, as well how this may occur in different contexts. By drawing attention to the language used in academic texts, learners can be made aware of how academic language is used to construct and convey meaning and thus also realise the importance of gaining competence in this form of language (Fang and Schleppegrell, Hyland, and Shanahan and Shanahan, in Achugar and Carpenter, 2014: 69). It is important for learners to be allowed, or rather, encouraged, to use exploratory talk when grappling with a new or difficult concept, as it allows them to speak about and thus solidify their understanding of the concept in a more relaxed, and thus more encouraging, environment (Setati et al., 2002: 135). In a multilingual classroom, it is only natural for this exploratory talk to include the learners' L1s and varied degrees of codeswitching (Setati et al., 2002: 135). It is thus apparent that learners' use of their L1 is an important learning tool. Pimm (in Setati et al., 2002: 135) posits that teachers can facilitate learners' movement from exploratory and informal talk to formal language use can be facilitated by either getting learners to write down their informal talk and edit and rework it into formal language, or to encourage learners to use more formal language from before the language is written down.

2.3.5 Computer-assisted language learning

In ESL and English Foreign Language (EFL) learning situations it is often difficult for learners to have access to authentic audiences with whom to interact in the target language (Johnston, 1999: 61). Computer-Assisted Language Learning (CALL) is a model of blended learning which utilises technology to assist learners' language acquisition. It allows learners to engage in meaningful interaction in the target language through a variety of online platforms (Johnston, 1999: 61). Hanson-Smith (1999: 199) points out that when using CALL a teacher should still create avenues for learners to meaningfully interact with the material and with other learners. I argue that in cases where blended learning occurs in the learners' L2 it is necessary to reinforce that learning through class or small group discussions in the l2 as well as activities conducted in the L2, in order for meaningful engagement in the L2 to take place.

It is argued that passive language exposure, for example watching television, is insufficient in order for a language to be acquired, and that meaningful interaction is vital in the language learning process (Johnston, 1999: 57). Children tend to have a higher drive for language learning when acquiring their first language and so meaning can be found in passive exposure; however, this drive is significantly less when learning a second language (Pinker and 1989 in Johnston 1999: 57). In line with this, it is unreasonable to think that learners who are learning through an L2 will improve their L2 acquisition simply by listening to the L2 being used.

There are several advantages to utilising videos as a means of CALL. Video content can be reinforced with imagery which can also aid learners' understanding of the language, and the videos can be paused and replayed at the will of the learner (Hanson-Smith, 1999: 190); a luxury not usually afforded in face-to-face language learning. Another language learning element of CALL is the written element. Once around 3 000 words have been learnt in an L2, most vocabulary is built through reading (Hanson-Smith, 1999: 200), and as such text is a useful inclusion in CALL. ESL learners are often encouraged to use a dictionary when they encounter unknown words; however, the time taken to do so can lead to the context of what the learner was reading being forgotten (Hanson-Smith, 1999: 203). In contrast the ability of glossaries to be hyperlinked to text allows for instant access to meaning, better facilitating vocabulary retention (Hanson-Smith, 1999: 203). This strategy should, however, be exercised with caution, as it could also result in learners using limited prediction or decoding strategies and becoming reliant on glossaries (Hanson-Smith, 1999: 203).

2.4. Mathematical considerations

2.4.1 Learning Mathematics through English as L2

> *"One must not confuse an inability to talk lucidly about mathematics with an inability to do or even understand mathematics"*
> (Pirie, 1998: 19)

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. While mathematics is embedded in a recognised language when it is spoken (for example, English), it is generally written with signs and symbols which are not part of that language, yet can be read out loud in that language (Pimm, 1991: 20). Setati and Adler (2000: 248) define informal language as the learners' everyday language, which is used when expressing mathematics, and formal language as the vocabulary and register learnt and used at school. Both types of language are generally present in mathematics classrooms, and both forms can be spoken or written (Setati and Adler, 2000: 248). A mathematical register does not consist solely of words, but also of a way of communicating (Halliday in Pimm, 1991: 18). Furthermore, mathematical English differs from everyday English as words hold different meanings or functions (Pimm, 1991: 19). While there are some words unique to mathematical English, other words are borrowed from ordinary English and altered (Shuard, 1982: 89). Everyday English and ordinary English may cause confusion when words have altered meanings, with the more formal grammar, and with the actual mathematical symbols (Pimm, 1981: 145). 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 and Adler, 2000: 262).

"Situated perspectives of cognition" (Brown, Collins, and Duguid, Greeno and Lave and Wenger in Moschkovich, 1999: 30) theorise the learning of mathematics as the understanding of mathematics as mathematical situations. Learners need to be able to communicate effectively about and within these mathematical situations, and they need the linguistic abilities, accompanied by the social understandings that go with these abilities, in order to do so (Moschkovich, 1999: 30). Moschkovich (1999: 30) suggests that the situated perspective is able to illustrate how learners' L1s and familiar contexts can act as aids in building their mathematical understandings.

Pirie (1998: 8) outlines six types of mathematical communication: ordinary language, mathematical verbal language, symbolic language, visual representation, unspoken shared assumptions, and quasi-mathematical language. Ordinary language is the type of language the learners use every day outside of the classroom, differing according to the learners' ages and language proficiencies (Pirie, 1998: 8). Verbal language is not restricted to spoken language; rather, it makes use of words to convey meaning in either spoken or written form (Pirie, 1998: 8). Symbolic language is restricted to written mathematical symbols (Pirie, 1998: 8). Visual representation uses visual realia[2] or writing, or a combination of the two, to convey meaning (Pirie, 1998: 8). Unspoken shared assumptions are not openly communicated, but underlie any communication that takes place (Pirie, 1998: 8). Quasi-mathematical language is used to speak about mathematics, but does not generally appear to be mathematical from an outsider's perspective (Pirie, 1998: 8). All of these means of communicating facilitate learning in different ways (Pirie, 1998: 8).

Learners form their conceptual understanding through combining their cultural and personal knowledge and experiences (Pirie, 1998: 10). Many children understand mathematical concepts in the everyday terms in which they made sense of them, irrespective of their ability to express the concept in mathematical terms (Pirie, 1998: 10). As such, mathematical language should be introduced only after the learner has consolidated these understandings, once the connection between the language and what it represents has been created (Pirie, 1998: 10).

When learners are learning in an L2 it is not always possible to differentiate between errors made due to conceptual misunderstanding or due to language proficiency (Moschkovich, 1999: 19). In order to be able 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

[2] Tangible objects from real life which are used to deepen learner's understanding of a concept or topic.

mathematics (Sfard et al., 1998: 41). Through communicating their thoughts, learners process these thoughts and synthesise them into more cohesive ideas (Sfard et al., 1998: 41). As such, talking about mathematics not only provides learners with opportunities to grow their language proficiencies, but also to refine and expand their mathematical understandings (Sfard et al., 1998: 41).

The meaning of formal mathematical language may be lost when teachers are not explicit about their movements between formal and informal mathematical languages (Setati and Adler, 2000: 139). 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) (Pimm, 1981: 148). Pimm gives the example of "'If the word *more* appears, then the problem is a take away'. How can this be reconciled with 'Charles earns four times more than Steve'?" (1981: 148), suggesting that it is most useful for such words to be understood in the context in which they are presented. Discussion is a key element of aiding mathematical understanding, and can be facilitated in a number of ways. Drawing from a variety of research and practices (the US NCTM standards, 1989; Ball, 1991; Cobb et al., 1993; Silver and Smith, 1996), Moschkovich (1999: 12) suggests that teachers can model and encourage mathematical talk (including learners talking to each other), encourage the learners to make inferences and estimations and explain or substantiate their claims, emphasise the processes involved in reaching the product, compare their ways of working with those of other learners, facilitate arguments in favour of and against statements, and work together with other learners.

When speaking in mathematical contexts there are different types of talk which may occur: expounding, explaining, exploring, examining, expressing, and exercising (Sfard et al., 1998: 49). Sfard et al. (1998: 49) describes exposition as a conversation with the content. Explaining is a conversation between a learner and a person with more expertise, within which the expert focuses on the learner's understanding (Sfard et al., 1998: 49). Exploring occurs when the learner interacts with the content, guided by a person with more expertise (Sfard et al., 1998: 49). Examining occurs when learners have their understanding checked by the person with more expertise (Sfard et al., 1998: 49). Expressing occurs when content is articulated in the process of making conjectures (Sfard et al., 1998: 49). And in exercising, the learner practices grappling with content with the aim of mastering it (Sfard et al., 1998: 49). When mathematics is expressed through language, be it everyday language or mathematical language, a person's presuppositions and understandings are imbedded in it (Pirie, 1998: 13). However, when it is written symbolically the space for interpretation is minimised (Pirie, 1998: 13). While a symbol may be able to hold multiple meanings, those meanings are finite and objective (Pirie, 1998: 13).

Mayer conceptualises the solving of mathematical problems into four elements: "translation, integration, solution planning and execution" (in Helwig et al., 1999: 115). Translation and integration rely on reading ability. Translation occurs when the learner interprets the mathematical problem into terms or ideas with which the learner is most comfortable, and integration is the process in which the learner compiles this information to create a whole understanding. As such, learners who have poor reading and comprehension skills are severely disadvantaged (Helwig et al., 1999: 115).

While competence in the register of mathematics will allow one to use the correct vocabulary and grammar (Moschkovich, 1999: 29), it is not sufficient. One also needs to know which mathematics community one is addressing (for example a mathematician or a primary school learner) and in which genre one is communicating (for example explaining or proving) in order to successfully communicate (Moschkovich, 1999: 29). Moschkovich (1999: 30) claims that while learners are discussing topics they have learnt (wholly or in part) in their L1 they are likely to use codeswitching, if learners have learnt certain topics of mathematics only in their L2, it is likely that they will use their L2 when discussing these topics. I posit that this may not necessarily be the case, as even if they learnt a topic only in their L2, many learners (especially learners who have not fully developed CALP in their L2) are still likely to use codeswitching to explore the concepts and procedures within said topic. Because mathematics has different discourse traits to everyday spoken language it is important for learners to use not only the LoLT, but also the *type* of LoLT needed within the discourse (Pimm, 1991: 21). One way of fostering formal language competence (CALP) is by allowing learners to report back on their work, where learners can be encouraged to write down their reports first, as well as rehearsing their report (Pimm, 1991: 22). Pimm (1991: 21) suggests two ways in which this can be done: learners can be encouraged to write down the spoken language they are using and edit it to make it more formal, or they can be encouraged to use the formal language when speaking in mathematical contexts. I suggest that one need not choose one method, but instead one can use a mixture of these methods over an extended period of time to allow learners to develop competence in these different types of speaking and writing.

The relevance of language in mathematics is often understated. It is often assumed that mathematics is easier than other subjects as it makes use of symbols rather than language. However, mathematical symbols need to be explained and discussed through language, and this can be done in multiple ways in multiple languages (Brown and Setati in Anthony and Setati, 2007: 218).

Howie (in Anthony and Setati, 2007: 233) reasons that mathematics teachers need to be proficient in English LoLT, as well as well trained in methods of accessing and using the learners' L1 in the classroom. Not only does this give learners the linguistic opportunity to access knowledge, but it also allows for greater learner participation and resultantly more learning can take place (Anthony and Setati, 2007: 233). Possibly as a result of the lack of training in accessing and using English and learners' L1s in the classroom, Newman (in Wales, 1990: 184) found that explicit language learning occurred almost exclusively during language lessons, and that very little explicit language learning occurred in mathematics lessons as focus was placed on problem-solving skills. Furthermore, it is not sufficient to note that mathematics is embedded in language and then rather focus on symbolic mathematics; it is important to also maintain relative mathematical narratives (Newman in Wales, 1990: 184). This narrative mathematics is particularly relevant in the South African context, where word problems test not only the learners' mathematical procedural abilities, but also their linguistic proficiencies. It is ironic that Standard Grade Mathematics in South Africa has been replaced by Maths Literacy, which consists largely of such narrative mathematics and, while intended to be easier for the learners mathematically, is in many cases more difficult for the learners linguistically. Taking into account the need for narrative and symbolic language in the South African curriculum there is a need for learners to be taught the mathematical concepts as well as the relevant vocabulary and language registers needed to understand and express these concepts (Dawe in Wales, 1990: 184). Newman (in Wales, 1990: 184) found that Grade 6 learners' mathematical errors often arose from misunderstanding the language used, rather than simply applying incorrect mathematical processes. Because we conceptualise in our L1, Wales (1990: 183) found that learners would translate difficult questions into their L1 as part of conceptualising and figuring out the question.

2.4.2 Fractions

Many 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: 1). 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: 2). When learners begin learning mathematics they are taught to reject fractions as numbers, because they are not whole numbers (Charalambos and Pitta-Pantazi, 2007: 300), 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. This is explained here using $\frac{1}{3}$ as an example. Firstly, a fraction can be seen as a part of a whole, for example $\frac{1}{3}$ can be seen as one part out of three equal parts; this is known as part-whole (Pantziara and Philippou, 2012: 63). Secondly, $\frac{1}{3}$ can be seen as one part to three parts; this is known as ratio (Pantziara and Philippou, 2012: 63). Thirdly, $\frac{1}{3}$ can be seen as one divided by three; this is known as a quotient (Pantziara and Philippou, 2012: 63). Fourthly, $\frac{1}{3}$ can be seen as a point on a number line (after 0 and before 1); this is known as measure (Pantziara and Philippou, 2012: 63). Finally, $\frac{1}{3}$ can be seen as one third of any quantity; this is known as an operator (Pantziara and Philippou, 2012: 63).

Learners tend to understand division-based fractions more readily because they already have a foundation in division through what they have previous learnt in mathematics (TLRP, 2006: 2). These understandings are also context-specific, as learners tend to understand fractions more easily in contexts in which learners are familiar and the objects involved are easily quantifiable and divisible (TLRP, 2006: 3). The intervention done by the Teaching and Learning Research Programme (TLRP, 2006) illustrates learners' pre-existing understandings of fractions and division, and argues that teachers should use these understandings to build on and solidify learners' knowledge of fractions. Furthermore, the TLRP argues that teaching should build on this knowledge with the outcome of learners' understanding fractions in both familiar and unfamiliar contexts (TLRP, 2006: 3), so that learners depend on their understanding of the concept rather than the context when working with fractions.

The Fractions course is of particular significance because fractions are renowned for being one of the most complex concepts in primary school mathematics (Charalambos and Pitta-Pantazi, 2007: 293).

One of the key concepts in fractions is that of the part-whole. In order to understand the concept of part-whole, learners must understand that the pieces into which the whole, area or discrete set are divided into should all be the same size (Charalambos and Pitta-Pantazi, 2007: 296). They should also understand that when all the parts are put together they should form a whole, or complete area or set (Charalambos and Pitta-Pantazi, 2007: 296). Learners should understand that the pieces become smaller the more parts the whole is divided into (Charalambos and Pitta-Pantazi, 2007: 296), although many learners initially struggle with this when asked, for example, whether $\frac{1}{2}$ or $\frac{1}{4}$ is bigger (TLRP, 2006: 2).

Learners need to understand that fractions exist as ratios to each other, and in order to understand this they should first understand that quantities can be relative to each other (Charalambos and Pitta-Pantazi, 2007: 297). They should also understand the role of a numerator and a denominator: that a numerator is the amount allocated and a denominator is the number of pieces into which a whole is partitioned (Charalambos and Pitta-Pantazi, 2007: 299).

Learners generally learn mathematics through procedural and conceptual approaches (Pantziara and Philippou, 2012: 61). Concepts can often be learnt through observing procedures and their outcomes in concrete contexts (Pantziara and Philippou, 2012: 61). However, familiarity with a procedure is insufficient for fully understanding a concept, meaning learners need to have procedural and conceptual understanding (Pantziara and Philippou, 2012: 62). With fractions in particular, many learners have understandings limited to procedural understandings, failing to fully understand the concept of fractions (Pantziara and Philippou, 2012: 62). While learners can often use either procedural or conceptual approaches to problem solving, those who are adept in conceptual approaches will be more equipped to solve more complex problems (Pantziara and Philippou, 2012: 62). When fractions are presented procedurally in textbooks and class lessons, learners tend to solve fraction problems based on following the procedures without thinking about how their procedures relate to concrete examples (Pantziara and Philippou, 2012: 66). For example, learners are often able to add fractions using the procedure of finding the lowest common multiple, but few learners are able to show or explain what this means beyond the procedure (Pantziara and Philippou, 2012: 66).

2.4.3 Mathematics and blended learning

With the introduction of blended learning, mathematics has been one subject which has, until recently, been viewed as unsuited to blended learning models (Harding et al., 2006: 403). This is because mathematics is a conceptual, rather than content, subject (Harding et al., 2006: 403). Resistance to the use of blended learning with mathematics stemmed from the belief that face-to-face learning was necessary to adequately demonstrate mathematical exposition, but this opposition began to fall away with the adaptation of more visual approaches to blended learning (Harding et al., 2006: 403).

When the University of Pretoria first introduced a blended mathematics course it was offered for one semester parallel to their traditional course in order for it to be evaluated and subsequently improved before scaling (Harding et al., 2006: 404). It is noteworthy that the pass rates of the blended learning course over three years were invariably higher than those of the previous years of classroom learning (Harding et al., 2006: 404). A similar approach was taken in this research by running an opt-in trial run of the multilingual blended learning course, after which it is evaluated and relevant changes will be made before it is scaled to other lessons in the programme.

2.5. Personal

Unfortunately, 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: 13). 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: 14) which is the belief that L2 proficiency is best attained through more exposure to it, albeit at the expense of the L1. Bearing in mind the multiple factors at play, the decline of the matric pass rate from 1975 to 1992 corresponds with more years in which learners were being taught in their L2 (Heugh in Plüddemann et al., 2004: 14).

The pedagogy supporting the LiEP's advocacy of additive bilingualism is not well-known beyond the academic world, and as such the misconception of better English proficiency being purely a result of more time spent using English is often more popular (NEPI in Probyn, 2009: 127). 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, and Pare, 2010: 280). Webb, Lafon, and Pare (2010: 280) argue that it is the responsibility of the department of education to inform the general public of the benefits of nurtured additive bilingualism and in this way sway popular opinion in favour of increased use of L1 in education.

In addition to the academic balance of language, it is also important that learning an L2 is perceived as enjoyable, supportive and inclusive (Krashen in Ovando and Collier, 1998: 185), as this will make learners more receptive to language learning and more confident in using the language themselves.

Additive bilingualism has great advantages not only in the realm of cognitive development, but also in the socio-psychological realm. Where learners are given opportunities to use and become proficient in their L1 as well as an L2 they feel like their language, and by extension their culture and individual identity, is validated and valued (Lindholm in Lindholm-Leary, 2001: 62). This is crucial in developing learners' positive self-esteem and also acceptance of cultures other than their own (Lindholm in Lindholm-Leary, 2001: 62), which is particularly relevant in the culturally divided and exclusionary climate repeatedly being experienced in South Africa in the form of xenophobia. Subtractive bilingualism, on the other hand, occurs when an L2 is learnt at the expense of the L1, essentially attempting to replace it, and has the opposite socio-psychological effects of additive bilingualism (Lambert in Lindholm-Leary, 2001: 62). It is noteworthy that subtractive bilingualism is most common where the L1 is a minority language and is replaced by a majority language (De Mejía, 2002: 40); however, in South Africa the language replacing many learners' L1 is the L1 of only a small minority of the population. This is both because of and reflective of the prestige status held by English, the L2 being learnt by so many, and the perception of the inferiority of African languages (De Mejía, 2002: 40).

2.6. Theoretical framework

In considering the literature it is possible to build a theoretical framework synthesising 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: 240). 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 and Appel, 1994: 26) 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.

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: 11), when one is learning through a L2 one depends on the context to make sense of the content, for example when one is meeting someone one is able to deduce meanings of greetings because those 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: 11). Therefore in second language acquisition 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 and Swain, 1986: 158). 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.

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: 233) and that certain linguistic skills and conceptual knowledge can be transferred from the L1 to the L2 (Cummins, 1979: 233). 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: 233). However, if the L1 is underdeveloped there will not be adequate linguistic skills to transfer and aid the development of the L2 (Cummins, 1979: 233), resulting in "semilingualism", or poor proficiency in both the L1 and the L2 (Cummins, 1979: 231).

When considering how these three theories inform each other 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, 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.

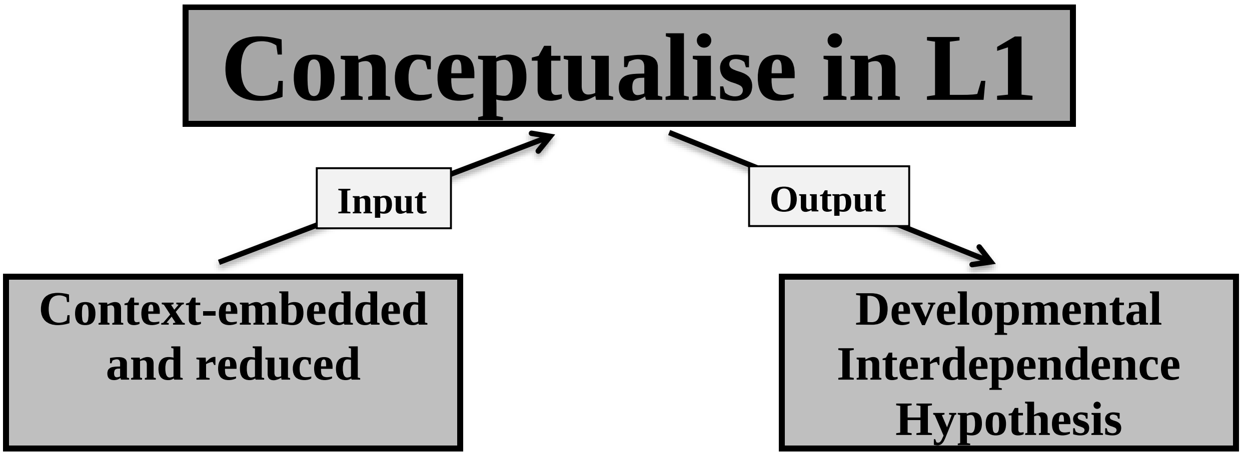


Figure 18: Theoretical framework

2.7. Conclusion

In considering how the socio-political, linguistic, mathematical and personal themes fit together it is evident that they weave a complex web of language within the education sphere. The vast majority of South African learners learn through their L2 for all but three years of their school careers because of a misinterpretation of "additive bilingualism" by the LiEP. These learners are then resultantly systematically disadvantaged and will likely struggle to grapple with the work they need to engage with at school. As the grades go higher schoolwork becomes increasingly complex, and mathematics is a case in point. In an attempt to attain socio-economic mobility through proficiency in English many learners and teachers are mired by the LoLT. Many teachers and learners use codeswitching in an attempt to balance the desire for English proficiency and the associated prestige with the need to understand concepts and content. Codeswitching is used to varying degrees and with varying levels of success.

Taking all of this into consideration it is therefore absurd to think that the current language policy paired with enforced and ingrained methods of teaching will truly assist most South African learners in achieving post-school success. It is imperative that the language in education situation is examined more seriously and that researchers in the field use their academic wherewithal to positively benefit those who need it most – the learners.

Chapter 3: Methodology

3.1 Introduction

For this research project it was necessary to employ a methodology that would allow for the research questions to be answered through the creation, implementation and evaluation of an experimental intervention. The methodology most suited to these needs is design-based research (DBR) and as such this is the methodology that was used in this research project. This chapter begins by explaining DBR in terms of its history, application, challenges, implementation and methods. Thereafter the methods of analysis will be discussed, and the relevant ethical considerations will be detailed.

3.2 Design

In considering the methodological design used in this research project I shall begin with a brief history of DBR and an explanation of what it is, followed by its strengths, appropriateness for this research, weaknesses and possible challenges, and the processes involved when conducting a design experiment using this methodology. I shall then describe how I followed this methodology in the creation, implementation and assessment of the design experiment, as well as describe the methods involved in this.

3.2.1 History of DBR

Conducting studies about how people learn requires contextual observations and experiments, and a methodological framework is needed in order to do this effectively (Barab and Squire, 2004: 2). DBR is one such framework, which has grown in popularity and application since its introduction to the field by Brown (1992) and Collins (1992) (Barab and Squire, 2004: 2).

Ann Brown (1992: 141) was trained as a learning theorist who conducted experiments in laboratory settings, and she notes the difficulty she had in transferring her research methods from laboratory settings to real life settings. Within this context, laboratory settings do not refer to white rooms with lab coats and microscopes, but rather spaces where learners are removed from the classroom context and tested in a setting apparently devoid of external influences. Brown (1992: 141) pioneered DBR by creating iterative new educational environments and assessing these interventions within their natural classroom settings. From the classroom setting, Brown (1992: 152) would use insights from laboratory experiments to add to these findings by doing further laboratory testing of trends discovered in classroom observations.

In reference to one of her early design experiments, Brown stated that “I do not have space to describe the multiple types of data we gather.” (1992: 151). This gives clear indication that DBR creates massive amounts of data which need to be carefully sorted, prioritised, and analysed. In order to best make sense of the various data, Brown (1992: 156) suggested mixing qualitative and quantitative methodologies according to what is being measured. Successful combinations of this type include her use of large amounts of data from a large scale experiment together with a focused analysis of a few selected research participants (Brown, 1992: 156). In doing this, Brown (1992: 156) would combine pre-test and post-test data from all the participants with selected observations and investigations of selected participants.

3.2.2 Application of DBR

Even though DBR 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 and Squire, 2004: 5). The videos created as part of this research are open-source and as such they are freely available for use via YouTube, and the translanguaging model can be replicated both for online videos and by teachers in classroom settings. It is this focus on the real-life context and application that sets DBR apart from methodologies such as laboratory experiments.

Design experiments do not exist with the sole purpose of putting theory into practice; they also aim to test theories and enhance them through examining their practical applications (Cobb et al., 2003: 9). These experiments aim to enable learners' optimal learning in certain domains (Cobb et al., 2003: 11); in the case of this research project the domain in focus is mathematics. In order to enable optimal learning, design experiments require creating ways of learning and developing and testing theories to explain these ways of learning and make them replicable and sustainable (Cobb et al., 2003: 9). The propensity for replication and sustainability of this research project are facilitated through the fact that the bilingual resource creator is not a language specialist. It is intended that the translanguaging model implemented in this research project can also be implemented by other teachers and facilitators who are bilingual and have knowledge of the subject they are teaching, but are not necessarily language specialists.

Collins et al. (2004: 18) note the importance of holistically evaluating educational interventions, such that it is not only learners' test scores that are measured but also their attitudes, motivation and hunger for knowledge. They argue that if research studies base success on test scores, we will end up with a world of people who score high marks in tests, but do not contribute to the improvement of their contexts (Frederiksen and Collins and

Shepard in Collins et al., 2004: 18). As such it is important that in the evaluation of this design experiment the socio-political, linguistic, mathematical and personal elements are all taken into account, rather than simply focusing on learners’ test score improvements. This was done in this research project by qualitatively evaluating learners’ reported experiences of the mathematics courses before, during and after the intervention, as well as their attitudes towards the incorporation of their L1 as LoLT.

Design experiments are put in place to test hypotheses; as such all elements of the experiment should be thoroughly assessed (Cobb et al., 2003: 10). The elements in this case consist of the socio-political, linguistic, mathematical and personal elements, as discussed in the analytical framework. Existing research is important both in the creation of a design and the assessment thereof, particularly in the justification of which elements of the design and the data are important in the experiment and which are superfluous to its development (Cobb et al., 2003: 10). In order to evaluate the context in which the design experiment is being implemented it must be carefully observed, either through the use of field notes or video recordings (Collins et al., 2004: 36). Field notes were taken throughout the implementation of this research, and all interviews were audio-recorded.

By the very nature of the context in which design experiments are conducted there are many influencing factors which are beyond the control of the researcher (Collins et al., 2004: 19). As such, it is important for researchers in DBR to take note of how all these factors interact with and influence the design (Collins et al., 2004: 19). Notable influencing factors in this research project include computer and internet connectivity problems and learners’ different attendance records. These factors have been noted throughout the presentation and analysis of this research experiment.

In a design experiment the research team gains more insight into the phenomenon it is investigating while the experiment is underway, and as such it is important that all of these insights are carefully recorded (Cobb et al., 2003: 12). These insights were recorded in the field notes taken during the implementation of the experiment, and are discussed in the presentation and analysis of this research experiment.

In studying a phenomenon one should first decide on whether one will take an idiographic, that is focusing on a select few, or nomothetic approach, that is focusing on a large number (Brown, 1992: 154). One should then decide on whether one will do a longitudinal or microgenetic design, that is, whether the phenomenon will be observed over a relatively long period, say a number of years, or a relatively short period of, say, a few days or weeks (Brown, 1992: 156). While longitudinal designs may appear to be more robust even simply in the amount of data they may accumulate, microgenetic designs have become common in studying very young children at certain developmental phases in learning, as well as older children with specific conceptual learning outcomes (Brown, 1992: 156). This research aims to consider the usefulness of a bilingual mathematics programme with a relatively small group of learners, from which it may be possible to make generalisations about the larger group of South African learners. For this reason I have used an idiographic approach. The design experiment implemented as part of this research project was limited by time and human resources such that it could only span one module within the programme. As such a microgenetic design was used, with the design experiment implemented over five weeks.

Design experiments make use of a variety of tools such as technology and curriculum design, and they are informed by theory (Barab and Squire, 2004: 1). In this research project I used technology to create and implement the bilingual online mathematics course which added to an existing supplementary mathematics curriculum. The creation of this design experiment was informed by the literature, particularly that which was outlined in the theoretical framework.

Pre- and post-tests are a useful means to assess learning variables such as understanding of content, reasoning behind answers, and dispositions towards learning, while surveys and interviews are useful means to assess systemic variables (Collins et al., 2004: 36). The pre-tests and post-tests were built into this design experiment in the form of the online pre-tests and post-tests that all learners completed before and after each video.

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: 34). 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 well recorded (Collins et al., 2004: 34). 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: 34). While there was no instance in which it was found that the design experiment of this research project inhibited learning, there was an instance where it was found that one of the videos did not provide optimal learning. The mathematics coordinator found that the bilingual resource creator had not illustrated a fraction in equal pieces, and this video was redone in order to equally represent the fractions.

There are several elements to consider when determining the success of a design experiment, one of which is whether and to what extent the design is sustainable without the presence of researchers (Collins et al., 2004: 36). In cases where the design is sustainable, the nature of DBR means that the designs can be instantly implemented because they have already been tested and refined during the implementation process (Cobb et al., 2003: 11). In the case of this research project the design is sustainable insofar as the bilingual resource creator is now able to create videos and glossaries independently of the researcher.

DBR is appropriate for this research project as it incorporates “the messiness of real-world practices” (Barab and Squire, 2004: 3) into the methodology itself, rather than having it as a superfluous factor, thus reflecting the true classroom situation. This is particularly relevant in the context of this research project where the context was rather “messy”: sometimes learners were absent or restless, or the computers did not work, or the internet was down, and so on. These factors are normal in many similar programmes, and as such it is important that they were incorporated into the study, rather than attempting to control these factors. DBR also includes the ethnographic element of noting social interaction (Barab and Squire, 2004: 3), another element which is not truly represented in laboratory testing. For example, this was done in this research project by noting how the learners interacted with each other around the experimental bilingual online mathematics course, and noting the conversations they initiated with each other and the facilitators. This contextualisation means not only that the research must illustrate how the experiment fits in with its context, but also how it is applicable in other contexts (Barab and Squire, 2004: 5). This also allowed for the experiment to look not only at the mathematical and linguistic achievements of the learners, but also at the socio-political and personal developments and interactions that influenced or arose from their participation in the course.

Through the constant design revision that is integral to DBR, it is more likely that the design will continue to improve over time (Collins et al., 2004: 19). After using theory to create a design, DBR also required that the research is related back to the theory in order to refine or further inform the theories from whence it came (Collins et al., 2004: 19). This is done through the process of writing up this research project, where theory and practice are synthesised. Thereafter it is possible for further iterations of the design experiment to be implemented.

Because of the vast amount of happenings within the context of the design experiment it is important to differentiate which elements are noteworthy and which are trivial, and note these distinctions in the research (Cobb et al., 2003: 10). This has been done throughout the data presentation and analysis.

The findings of the research experiment should show the outcomes of the experiment in terms of the socio-political, mathematical, linguistic, and personal elements. Furthermore, the findings and recommendations from this research project also point to how this contributes to the broader research sphere and particularly how this research relates to the broader South African educational context, as suggested by Barab and Squire (2004: 8).

3.2.3 Challenges

There are several challenges one needs to be aware of when conducting DBR. Firstly, researchers bring a human element into the research: being objective becomes difficult when one is integrally linked to that which one must evaluate, and in the implementation process the researcher also needs to allow the design to be implemented without external interference from the researcher (Barab and Squire, 2004: 8). This was experienced in the implementation of this experiment as I both created and evaluated the experiment, and as I am the literacy coordinator at OLICO Youth I naturally had close ties to the learners and facilitators involved in this experiment.

Furthermore, each time the design is altered (albeit this is central to DBR) the implementation of the design becomes more synthetic (Barab and Squire, 2004: 10). This could happen if, for example, it was found that the videos were too long and needed to be made shorter to hold the attention of the learners. In doing so it is possible that the person creating the videos would then use shorter explanations, but that these explanations would not fully explain the concepts, and then even though the codeswitching model was successfully employed the learners would not be gaining adequate understandings, thus undermining the aim of the experiment. These are what Brown and Campione refer to as "lethal mutations" (in Collins et al, 2004: 17) – where the design is changed in unintended ways through its implementation, thus detracting from the underlying principles of the design. It is easy to see how this could happen when one considers the number of human elements involved in implementing the design and the number of unspecified impromptu decisions that need to be made throughout its implementation (Collins et al., 2004: 17). As Collins et al. (2004: 17) put it, "Designs in education can be more or less specific, but can never be completely specified." In order to account for these elements in implementation, a profile should be drawn up for what the critical elements of the implementation were and how they were implemented

(Collins et al., 2004: 34). The critical elements of implementation for this research project are illustrated in the following table:

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 reversion the videos.
The isiZulu used should be familiar to the learners.	This was done at the discretion of the bilingual resource creator, and 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 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 for the learners 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 followed by completing a post-quiz.	This was automated on the computers.
Learners must watch the videos in the correct order.	This was automated on the computers.
Learners must know how to use the glossary.	The facilitators and I showed the learners how to use it and checked that they had understood.

Table 1: Critical elements of implementation

Also, while another central tenet of DBR is its real-world context, this too provides challenges as the contexts are often so far beyond the control of the researcher (Collins et al., 2004: 16).

Data collection and synthesis is another challenge in DBR, as there is a tendency for researchers to collect vast amounts of data with the hopes of gaining in-depth understandings, which use resources to collect, and are then unable to analyse or sort through all the data that has been collected (Collins et al., 2004: 19).

When there are large amounts of data the relevant data needs to be selected. This makes DBR susceptible to the Bartlett Effect, where the researcher picks out data that illustrates the success of the research or the point that is being made, without this being fully representative of all of the data (Brown, 1992: 162). In order to counter this, Brown (1992: 173) suggests representing data that is “general, reliable, repeatable” (Brown, 1992: 173), however unexciting or uninspiring it may appear to be, as this makes the reported elements of success more viable. In order to make the data collected in this research project meet these criteria the following has been done: the data collection methods are clearly detailed such that external parties may recreate the experiment themselves; in the presentation of quantitative data all of the data is transparently represented and emerging trends are discussed, irrespective of whether or not they illustrate the success of the experiment; and in the presentation of qualitative data observations both supporting and opposing the success of the experiment are presented. Another apparent misrepresentation of data may occur with the Hawthorne Effect, which states that any intervention will have a positive impact, irrespective of the merits of the intervention (Brown, 1992: 163). While this effect is difficult to prevent in most cases, this experiment is somewhat of an exception as it is possible that this particular intervention may also have a negative impact on learners' performance, as the learners are not accustomed to learning through their L1. The reality principle, which was touched on earlier, is the criticism that interventions have a limited lifespan and will be unlikely to continue their success in the absence of the research team, emphasising the need to ensure the design is replicable and sustainable independent of the research team (Brown, 1992: 171). Bearing this principle in mind this research has sought to create an experiment that is realistically replicable in any situation with adequate resources, that is to say that any person who teaches, tutors or facilitates mathematics classes may use the codeswitching model used in this experiment. In order to make this a reality close ties will be kept with OLICO Youth in order to implement this within other branches as OLICO Youth expands.

3.2.4 Implementation

Before a design experiment is implemented in a classroom, the research team should assess and note learners' pre-existing capabilities, classroom practice and so on, upon which the design can then be built and implemented (Cobb et al., 2003: 11). This information could come from investigation in that specific context or, where research already exists, by drawing on the existing research (Cobb et al., 2003: 11).

In order to inform this design experiment, I made projections about learners' use of codeswitching based on my previous research, existing literature, and qualitative observations of the participating learners. My previous research consisted of ethnographic case studies of codeswitching in classrooms in a Grahamstown school, where it was found that while one teacher improved learners' language proficiencies by drawing attention to intentional codeswitching (von Witt, 2013: 52), another teacher limited learners' language growth by explaining new and difficult concepts in English only, switching to isiXhosa afterwards to explain everything again to individual learners (von Witt, 2013: 44). The existing literature has been discussed extensively in the literature review, with two key findings influencing the design: the development of BICS and CALP, and the transfer hypothesis. This was used to inform the translanguaging model as illustrated by the theoretical framework used in this design experiment (see fig. 18). Qualitative observations were conducted by me and my colleagues prior to the design experiment, where it was found that the majority of learners in this study have strong BICS in English (albeit with limited fluency in some cases) and their L1, but their English CALP was weak and their L1 CALP was only slightly stronger. Based on these observations and inferences, it was projected that learners would gain a better understanding of the mathematics video concepts if they utilised translanguaging in the learners' home language. The process of creating these videos is detailed later in this chapter.

The design for this experiment centred around creating a bilingual option for the pre-existing Fractions course on the OLICO Youth learning website. This was made bilingual by (a) recreating the videos using translanguaging in English and isiZulu and (b) incorporating a bilingual glossary of terms which was embedded in the online programme and included in learners' homework books. I created the design by reviewing the literature, considering the Diepsloot context, and paying attention to the needs of the learners.

From the literature I have drawn on Cummins' theories of BICS and CALP (Cummins and Swain, 1986: 153), CUP (Cummins in Lindholm-Leary, 2001: 55), and the transfer hypothesis; Makalela (2015) and Garcia and Wei's (2013) theories of translanguaging, as well as the assertion that we conceptualise in our home language (Cummins, 1979: 240). In considering this holistically it can be deduced that many South African learners have the propensity to learn multilingually, and indeed that this would likely be beneficial to them. Despite the existing literature, there are very few classroom support

A similar project is one run by Clickmaths in collaboration with the Mathematics department at the University of Cape Town (OpenUCT, 2014), where Khan Academy videos were translated wholesale into isiXhosa and used by learners in Cape Town. While this is likely to improve learners' understanding of mathematical concepts, it is problematic in that learners are still expected to interact with these concepts in English within their school curriculum. Ideally, learners should be able to conceptualise and build understandings in their L1, and then also be able to recognise and articulate this in their L2. Unfortunately the outcomes of this project have not been made publically available, creating uncertainty of whether the project was able to facilitate conceptual understanding and whether learners were still able to interact with the subject matter through English as the LoLT.

Through considering these factors I created a 'translanguaging model', in which Khan Academy-style videos created by the mathematics coordinator at OLICO Youth were adapted into isiZulu and English together. The aim of doing so is to give learners access to the concepts in their home language, as well as the ability to interact with these concepts in English. Because we conceptualise in our home language (Cummins, 1979: 240), each concept was introduced in isiZulu. This concept was then expanded on using increasingly more English. This process is repeated throughout the video, using gradually more English as the video progresses, and a recapitulation of the video is given in English. The following processes were followed in the creation of the videos:

3.2.4.1 Creation of video text

1. I watched and transcribed the pre-existing videos that had been created the previous year by the mathematics coordinator. The figure below is an illustration of one of these videos:

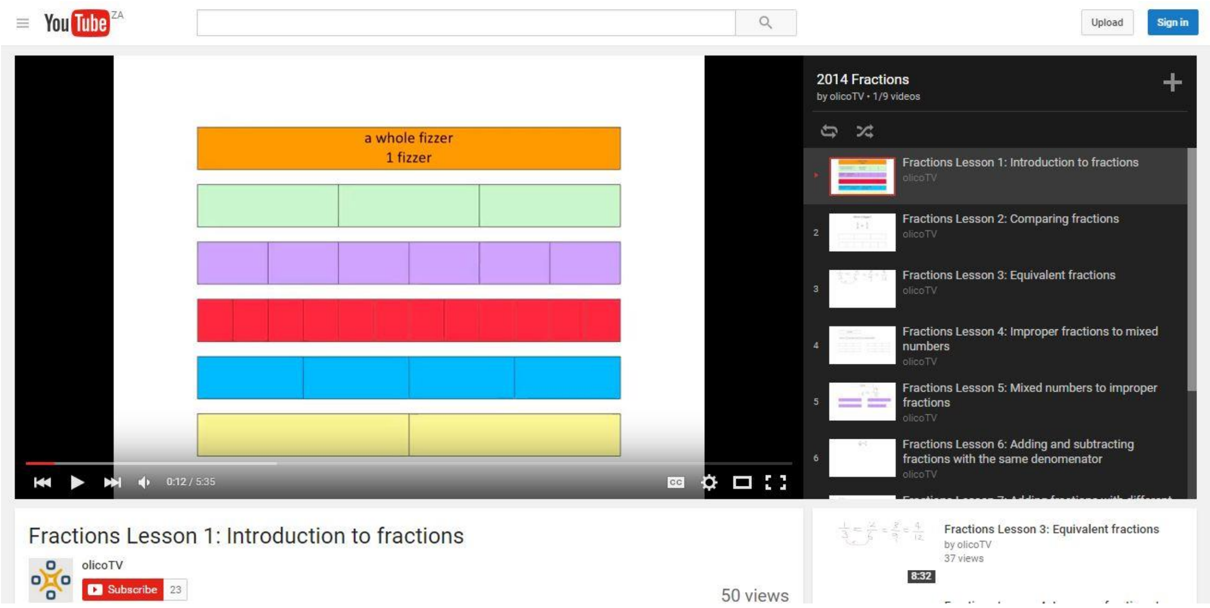


Figure 19: English Fractions videos

2. I identified the main concepts that are presented in the video.
3. For each concept I identified the introduction of the concept and the development of the concept. I then illustrated this by colour-coding the text, using green text to denote the introduction of concepts and orange text to denote the expansion of concepts. This step was directed by the theoretical framework of this research project. Introducing concepts in isiZulu contextualises the learning that is taking place. This is important because when learning a L2 one relies on drawing from the context to make meaning (Baker and Hornberger, 2001: 43), making it easier for learners to make sense of what was being said in English and simultaneously improving their English proficiency. As the video progresses learners gain more and more contextual information, so that

towards the end of the video they have enough contextual knowledge to infer meaning from the English being used.

4. The colour-coding is illustrated in fig. 20 below, which serves as a visual representation of the different colours used for each language. For a detailed reading, please see Appendix A for the corresponding transcription.

Fractions Lesson 8: Multiplying fractions
Blue is slide heading
Green is isiZulu
Orange is English

Slide 1: Coloured-in rectangle
We're going to have a look at multiplication of fractions today. We're going to start with having a look at the logic, and then we're going to see how we can do it nicely and easily. Let's say I have a cake, and I've decided to give you two thirds of my cake. What do I do? I cut it up into three pieces, and I give you two of them. So there's your two thirds nicely in green. You're feeling generous, and so you decide that you are going to give half of that two thirds that you've got to your little brother. So let's think about what you'll give to your little brother. What you will need to do is cut that in half, so that you can then say, ok, this bit's going to my brother, and this is the bit that I get to keep. Let's have that picture nice and neatly so we can talk about it.

Slide 2: Coloured-in rectangle with dark green
So half of two thirds will be this dark green portion over here. So half of two thirds, we can see quite easily, is one, two pieces, out of one two three four five six pieces, so it is two over six. In other words, one half of two thirds gave me two sixths. We can see easily how to get that answer; one times two is two, and two times three is six. So multiplying fractions is very easy, you just multiply the numerators together, and multiply the denominators together.

Slide 3: ¾ x 5/7
Ok. So now we know how to do it, we can just get the answers straight away. What is three quarters times five sevenths? Well, we multiply the numerators, three times five gives me fifteen, and we multiply the denominators and we get four times seven which is twenty-eight. We now see if this thing can be simplified at all. Well, no it can't actually, because fifteen is just made up of five times three, and three won't go into twenty-eight, and nor will five. So fifteen over twenty-eight is as simple as it gets. Ok, I want you to open your homework book, and there is this example there that you need to try.

Slide 3: 3/5 x 2/9
Three fifths times two ninths. Pause the video now and do it quickly in your homework book and we'll discuss it later. Ok. So the simple way is just to say three times two is six, and five times nine is forty-five, and now I've got to go and simplify that. Well I can actually see there is something that can go into both of these. Three can go into both of these. So if I divide the top by three I get two, and if I divide the bottom by three I get fifteen. In other words, I'm doing the same to top and bottom, divide by three divide by three, and I get two fifteenths which is my simplified version. Now, if we're clever, we can actually avoid quite a lot of extra work. Because, if we cancel before we multiply, we will end up not having to do nearly as much simplification, and believe me sometimes the multiplying you will have to do will end up being really big horrible numbers unless you do the simplification. So let's have a look at exactly this problem again, but let's do it more cleverly. If we have three over five times two over nine, we know that what we have to do is we have to multiply the numerators together, and then multiply the denominators together. But we also know that when we have a fraction like this, what we do to the bottom, divide or times, we also do to the top, divide or times by the same thing. And let's have a look right here where we are. Before I've done anything I can see that I've got a three on the top, and a nine on the bottom, both of them can be divided by three. So I can go and say, divide the top by three, that'll just leave me with a one, and divide the bottom by three, that will leave me with a three. So I've got no problems, I'm doing exactly the same to top and bottom of my fraction, so I'm not changing anything. Then I get, one times two is two, five times three is fifteen, and I get my answer of two fifteenths. So the idea there is just to do your simplification before you do your multiplication because that'll make it easier and quicker. Let's look at an example like this.

Slide 4: There are 24 learners in my class. ¾ of the learners are girls. How many girls are in my class?
There are twenty-four learners in my class. Three quarters of the learners are girls. How many girls are there in my class? Well I know that three quarters of the twenty-four are girls. In other words what I need to do is, three quarters multiplied by twenty-four. Now you should remember that I can write any whole number as a fraction by just putting it over one. Twenty-four over one is the same as twenty-four, just like five over one is five, a hundred over one is the same as a hundred, and a million and twenty-three over one is the same as a million and twenty three. So we're back in the same situation that we've been in. So we can multiply numerators together and we can multiply denominators together and get our answer. Here's one of these examples where if we actually just do the multiplication we're going to end up with a nightmare. Three times twenty-four is a big calculation to do. So let's go with my idea, let's just say we've got three times twenty-four, over four times one. Now before we actually go and do all that tedious multiplication, let's see if we can cancel, because that'll make it simpler. I notice that I've got twenty-four at the top and four at the bottom. Four can divide into both of them, and our rule for fractions is as long as I multiply or divide the top and the bottom by the same thing, I haven't changed the fraction. So let's divide through by four. That'll give us one. Divide this by four, that'll give me six, and now I can get my answer without having to do my nightmare calculation. Three times six is eighteen, and one times one is one, so I get my answer of eighteen over one, and of course eighteen over one is just the same as eighteen.

Slide 5: 3 2/3 x 3 2/5
Ok. If we need to do a multiplication and we've got mixed numbers, my same rule for mixed numbers applies: just turn them into improper fractions and then you'll be fine. Ok, so let's turn these into improper fractions. Three threes are nine, plus two gives me eleven over three. And two and two fifths, two fives are ten plus two gives me twelve, so I have got twelve fifths. Again, big calculations if I don't do any simplification first; I'd have to do eleven times twelve and three times five and then go and see if I can simplify at the end. It's much easier if I do it first like this: I say eleven times twelve over three times five and I see ok, can I divide top and bottom by the same thing and I see yes, I can immediately see I can divide top and bottom by three, that goes once, that goes four times, and so I will get eleven times four is forty-four, and five times one is just five. And if I want to turn that back into a mixed number I say five goes into forty-four eight times with four remaining, so that's eight and four fifths.

Slide 6: Blank slide
Ok. Try quickly for yourself, this is in your homework book for you to try, do two and one third multiplied by one and two sevenths. Pause the video now and do it, and then we'll check it together. Ok you should have got the following. Seven over three, two threes are six plus one is seven, multiplied by seven times one is seven plus two is nine so that's nine sevenths. Let's just see if we can simplify before we continue. Well this is a great simplification right? We can divide top and bottom by seven and we can divide top and bottom also by three. And so our answer ends up being, one times three is three, one times one is one, three over one, and of course we know that three over one is just three.

Figure 20: Colour-coded video scripts

5. I passed the colour-coded transcription on to the bilingual resource creator, who then reversioned the green text into isiZulu. This English and isiZulu text then formed the basis of the script he would use when recording the videos. An example of this script can be seen in Appendix B.

3.2.4.2 Creation and recording of video audio-visuals

1. *Explain Everything* is a video-making application that works in a similar way to Microsoft PowerPoint. One first creates slides, which can consist of images or PDFs, which one then arranges in the order in which one wishes to present them. Thereafter one records over these slides, in which time it is possible to speak, write, and use a

digital LED-style pointer. The layout of slides is illustrated in fig. 21, and an individual slide in editing mode is illustrated in fig. 22.

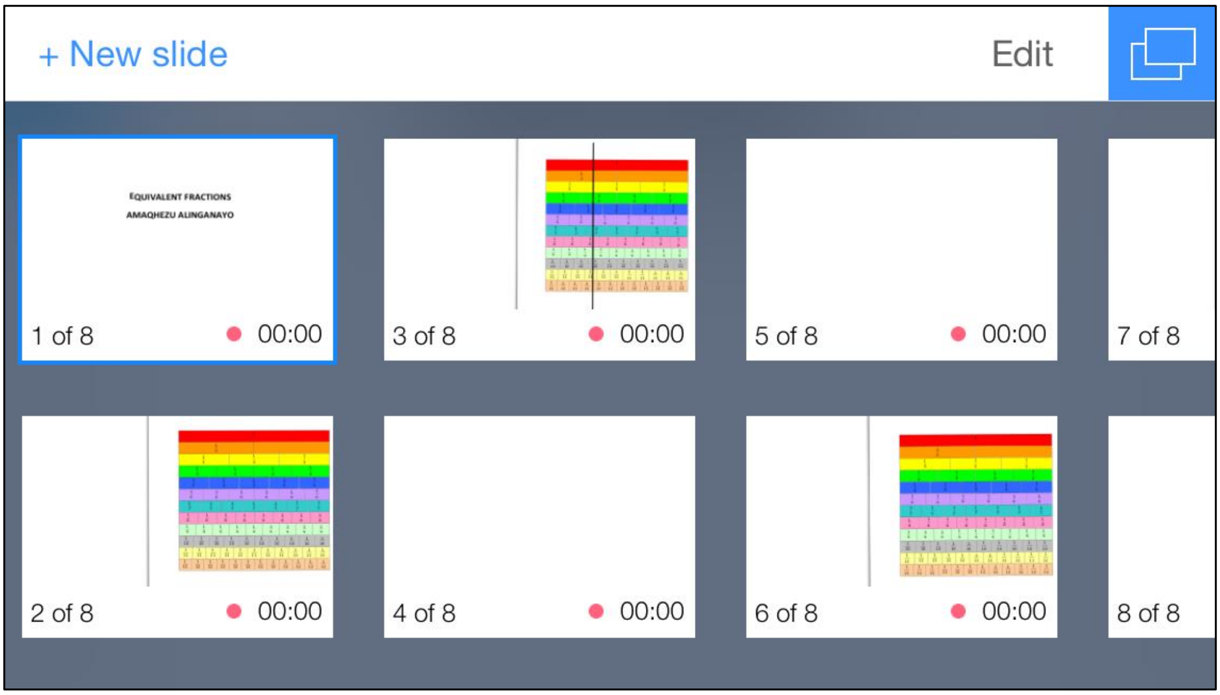


Figure 21: The selection of slides used in a Fractions video

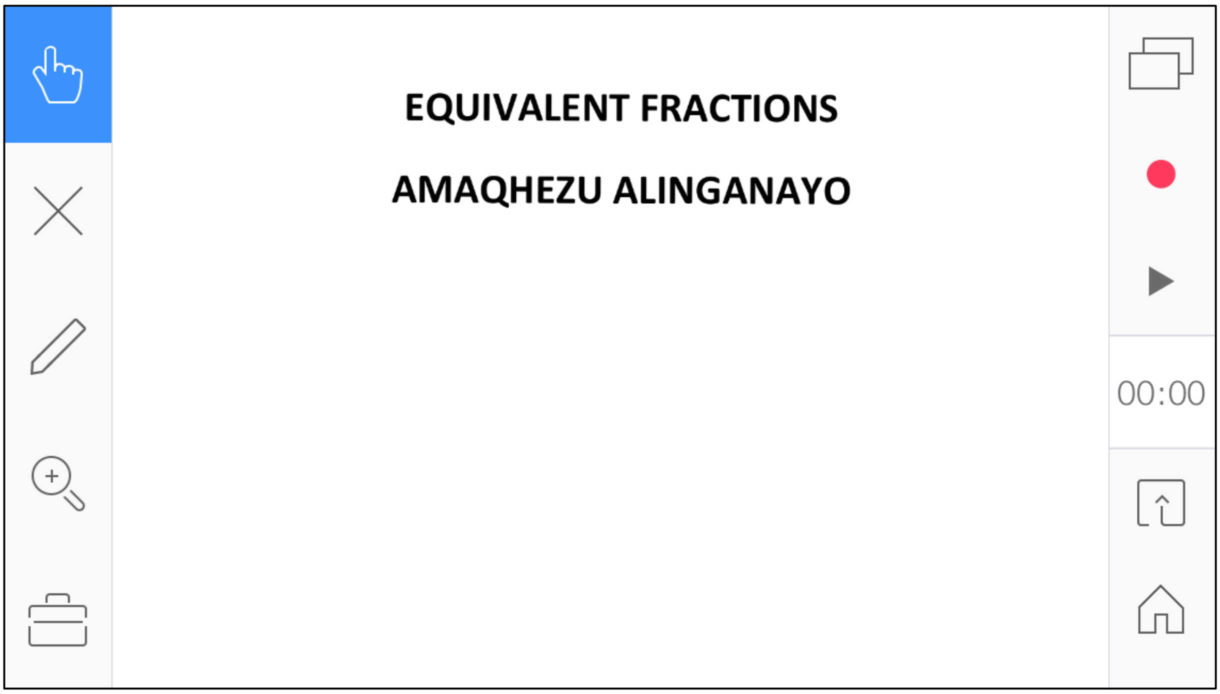


Figure 22: Explain Everything interface

2. The mathematics coordinator had created English-medium slides for the fractions videos the previous year. I used these slides as the basis of the English-isiZulu bilingual videos. Whenever the accompanying text was in English, I kept the slide as it was initially created in English. Whenever the accompanying text was in isiZulu, the bilingual resource creator reversioned the accompanying slide into isiZulu. In the case where both English and isiZulu were used to accompany a slide, the slide was written on bilingually.

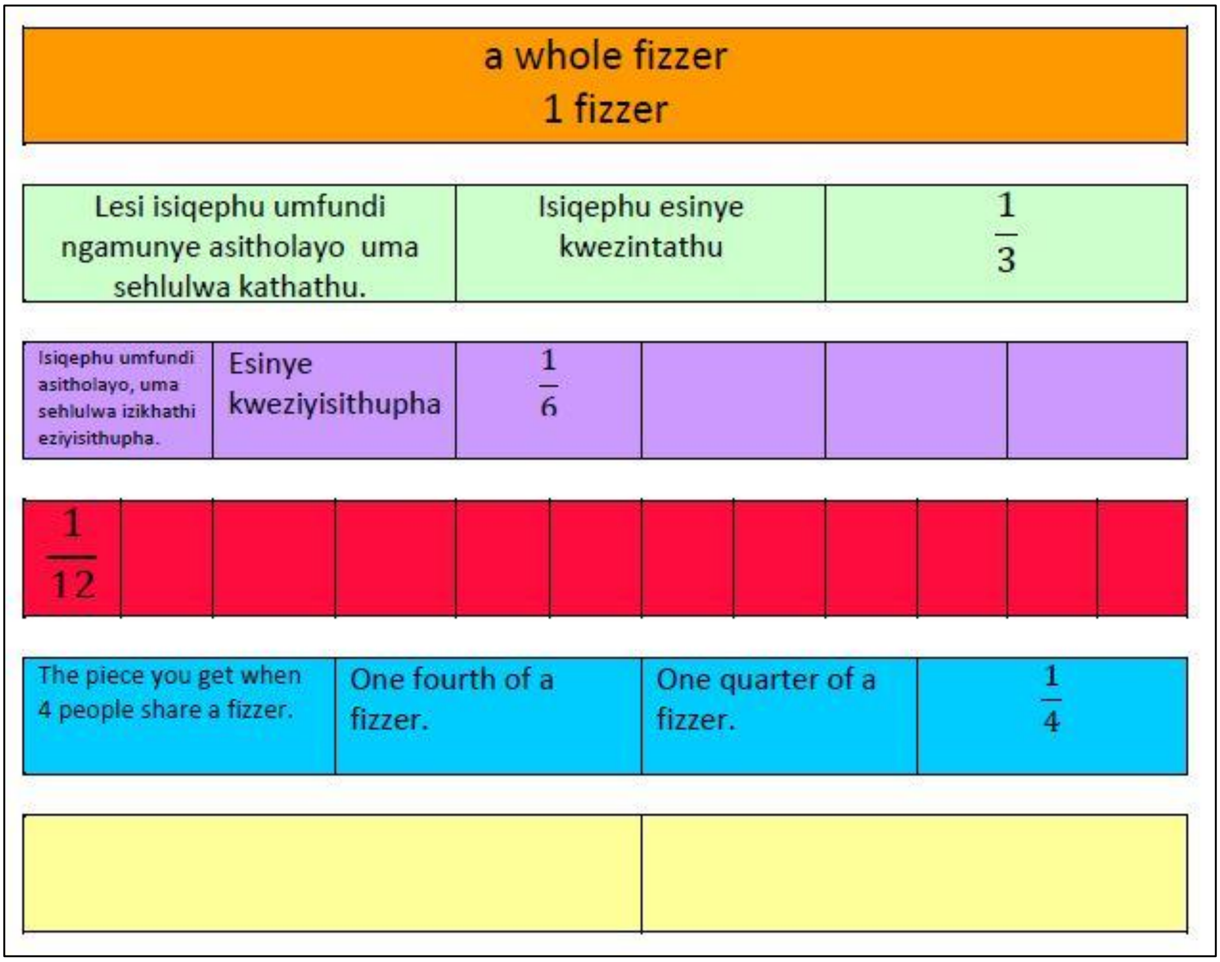


Figure 23: Bilingual slide from Fractions Lesson 1

3. Once the relevant slides had been reversioned the bilingual resource creator recorded the video. He read from the transcribed and reversioned script and used the original English-medium videos to guide his use of writing and the LED-style pointer.

3.2.4.3 Creation of the bilingual glossary

The English-isiZulu bilingual glossary was created by the bilingual resource creator and me and made available to all the learners doing the experimental course through hyperlinks in the online course and as a printed page in their homework books. Difficult terms were identified during the online OLICO Youth Fractions course last year when it was run in English with a different group of Grade 7 learners, during which time I made note of words the learners did not understand. I gathered this information by asking learners what some of the terms meant, and noting when learners asked what terms meant. During this time an attempt was made at building a collection of difficult terms, and learners were encouraged to contribute to this by writing down terms they would like a definition for and sticking them on the 'glossary board', or by notifying a facilitator when they did not understand a term. This did not work however, as only one learner submitted one term. This could be for a number of reasons, which could include (a) that the glossary building activity was not fully incorporated into the teaching and learning space and was instead seen as an additional task, (b) that learners did not want to expose their lack of understanding, or (c) that learners did not think a glossary would be useful. The terms that were identified last year were included in the glossary and also used as a guideline for which other terms may be difficult and were to be included in the glossary. The intention was to give learners explanations of the terms they encountered in the experimental Fractions course both in English and isiZulu, using familiar context-embedded language as discussed in the theoretical framework. The aim was to give learners the opportunity to access meanings of terms in whichever language they were more comfortable. 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 last 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 which includes reading textbooks, watching videos, attending classes and so on.
3. I then passed this list on to the bilingual resource creator and he gave short definitions in isiZulu, also similar to an explanation he would give to a learner in class. 'Borrowing' (Mawonga et al., 2014: 73), that is, using English terms within isiZulu, and 'paraphrasing' (Mawonga et al., 2014: 74), 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 is 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 both the English and isiZulu short explanations would pop up.

5. I printed these glossaries and attached them to the homework books of all the learners doing the bilingual course, so that they could refer to them while doing their homework.

As is common with DBR, many people were involved in the implementation of the design. Below follows the process of design implementation, from creation to implementation to review.

Before the creation of the design experiment tests and discussions were held to explore learners' English and mathematics abilities and learners' and parents' attitudes towards different languages in the learning and teaching environments. At the beginning of the year diagnostic mathematics assessments created by the OLICO Youth maths coordinator were conducted with all Grade 7s at OLICO Youth in order to ascertain learners' existing knowledge. In these assessments it was found that the learners' mathematical proficiencies were in line with Spaull and Kotze's (2015: 21) projections outlined in Chapter 1, section 1.2.1.2, and were roughly three grades behind grade level.

Quarterly parents' meeting are held at OLICO Youth to discuss the term's programme with the parents and learners. At the first parents' meeting of 2015 a focus group discussion was also held, in which parents' attitudes toward learning through English and L1 were discussed.

At the OLICO Youth Winter School, which consisted of intensive mathematics sessions during the June 2015 school holiday preceding the introduction of the Fractions course, all OLICO Youth Grade 7 learners participated in questionnaires (see fig. 61 and Appendix C) around their experiences of the Maths videos and their attitudes towards English and their L1s as LoLTs. After these questionnaires were completed, volunteers conducted focus-group interviews with the learners to further explore their thoughts and attitudes.

The online Fractions course was already in existence from when it ran for the first time in 2014. The OLICO Youth mathematics coordinator created the Fractions videos and content, and the OLICO Youth project co-founder created the online course and uploaded all the content.

3.2.4.4 Video evaluation and adaptation

After making the first three videos, the mathematics coordinator put me in touch with the quality assessor, a PhD candidate whose research focuses on language and mathematics. She provided valuable feedback on language equivalence, such as noting the ambiguity of the isiZulu word *izikhathi*[3] and the preference for rather using *iziqephu*[4], and on mathematical content. The mathematics coordinator and the project coordinator also provided feedback on the videos, particularly on the mathematical elements such as the drawing of fractions, and the technical elements such as the length respectively.

After the creation of Fractions Video 2 the mathematics facilitator and quality assessor pointed out that the fractions drawn in the video were not divided into equal parts[5], 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). However, this edit was made after some of the learners who were ahead had already watched Video 2, so these edits were seen only be the remainder of the learners. This may affect some of the learners' results in the Fractions quizzes as the learners who watched the video before it was edited may not have grasped the concept of fractions consisting of equal parts.

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 try to keep videos below 10 minutes, as he and the mathematics coordinator had found from previous experience 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: 160) 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 he could 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 then understand a subsequent explanation. In our discussion we spoke about how the mathematics coordinator explains things in one

[3] Times
[4] Parts
[5] It is important for representations of fractions to be equal so that learners can grasp the idea of equivalent fractions.

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 more 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 aligned much more closely with the times of the English-medium videos.

Due to several difficulties with the computers the bilingual resource creator and I were not able to complete all the videos before the course began. As such, we were working on the videos while the course was running; however, we always ensured that the videos for that day's lesson would be up in time. 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.

In noting the personal attitudes that would affect learners buying into the new course, learners' averseness to learning mathematics in isiZulu became clear as the learners argued that it would make it more difficult. It thus became obvious that this attitude needed to be addressed, and that we needed to assure the learners that the isiZulu used in the course would be mixed with English and would be the same type of isiZulu that they use with each other and with OLICO Youth tutors – not the formal written isiZulu they are expected to use in the isiZulu class at school. The bilingual resource creator and I created the following fun poster using a mix of English and isiZulu to make the bilingual Fractions course more appealing:

Figure 24: Fractions bilingual poster

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. In this discussion I explained the differences between the courses, clarified what kind of isiZulu would be used, asked learners which course they would like to do and if they would like to share their reason for their choice with me. Once learners had decided which course they would like to do I gave them the enrolment key they should use to sign up: learners doing the English-medium-only course enrolled using e*nglish* and those doing the bilingual-medium course used the word *zulu* as their respective enrolment keys.

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. It was helpful that the learners already knew me as a member of the OLICO Youth team, so that the typical influence of a researcher's presence was less pervasive, and also that learners were constantly asked to comment on and evaluate elements of the course, so they were able to give relatively uninhibited feedback.

Once the learners had completed the Fractions course I conducted one-on-one interviews with selected learners from a range of performance levels. These interviews were audio recorded and learners' writing was also kept for analysis. The purpose of these interviews was to investigate learner's perceptions of the course, as well as their understandings of the concepts taught in the videos.

In conclusion of the design experiment, the mathematics coordinator, the project co-founder, the mathematics online course facilitators, the bilingual resource creator and I had several discussions about our observations of the Fractions course; its successes, weaknesses, and recommendations for further iterations.

As per DBR methodology, the design experiment was under constant revision throughout its implementation. The translanguaging model was first introduced by me in my Honours research in 2013, after which it was revised several times by my research supervisor and me before the bilingual resource creator and I began with the creation of the videos. Once we had reached agreement on the model to be used, the bilingual resource creator and I began with the video creation.

3.2.4.5 Quantitative data collection

As per DBR methodology a range of data collection methods were used according to the context, with both quantitative and qualitative data being collected.

Quantitative data was collected in the following ways:

1. Mathematics and literacy diagnostic tests. These were administered at the beginning of the year and were administered by the mathematics coordinator and myself. The creation of these tests was informed by theory and CAPS outcomes as outlined by the South African Department of Basic Education. The mathematics and literacy tests were then marked by the mathematics coordinator and myself respectively. This data is not discussed in detail in this research project; rather, it was used to assess whether there was a need for a bilingual mathematics intervention.
2. Likert-type questions in learners' questionnaires (see fig. 61 and Appendix C) before the implementation of the Fractions course. These questionnaires were administered to all learners during the OLICO Youth Winter School, which is a week of mathematics, literacy and life-skills lessons during the 2015 June school holiday.
3. Pre- and post-quiz scores. These quizzes were completed by the learners online before and after watching the videos. The Moodle computer programme automatically gathered and stored learners' quiz results, which were then accessed through the back-end of the Moodle.

4. The number of clicks learners made on the online hyperlinked glossary terms. The Moodle programme automatically identified and stored every click each learner made on the online glossary.

3.2.4.6 Qualitative data collection

Qualitative data was collected in the following ways:

1. Observations of learners' ability to articulate their reasoning, motivation and level of engagement. Observations of learners' ability to articulate their reasoning (in written and spoken form) behind the mathematical processes they used was observed through their test answers and discussions in class from 2014 until the time of writing, by the mathematics coordinator, the OLICO Youth branch coordinator and myself. Motivation and engagement was measured by the visible elements of learners' attitudes and the feedback they provided in written questionnaires and informal discussions.
2. Observations of learners' views on the use of L1 in academia. This was collected through open-ended questions in surveys (see fig. 61) and group discussions (see Appendix C) which were completed during the OLICO Youth Winter School and facilitated by volunteers.

Throughout the creation and implementation of the design experiment we faced the challenge of making the project sound viable and beneficial to the parents and the learners. While some parents were insistent that learners should learn only in English, because that is the LoLT, others affirmed that learning bilingually would optimise their children's understanding and English proficiency. Many of the learners stated that they were averse to learning through their L1 as they believed it would make mathematics even more difficult than they already found it to be.

Once we had enough support to create the bilingual course, we then had to figure out what languages to use. The most common lingua franca amongst the OLICO Youth learners is Sepedi, and isiZulu comes a very close second. It was decided that we would undertake the experiment using isiZulu because I would be better able to interact with the project creation as I have intermediate proficiency in isiXhosa, which due to its Nguni language grouping is similar to isiZulu, while I have extremely limited proficiency in Sepedi. Another difficulty I encountered with this was that my entry-level isiZulu proficiency was not sufficient for me to meaningfully engage with the videos and their creation, and so I was heavily reliant on my faith in the bilingual resource creator for this and the feedback we received from the quality assessor.

However, once this was decided we then needed to decide on what type of dialect of isiZulu to use – particularly whether we should use formal isiZulu or the more informal "Diepsloot isiZulu". We then decided that since the primary aim of the experiment was to give learners access to mathematical concepts in language they understand, we decided that we would use the more informal Diepsloot isiZulu. In doing so we also noted that these videos may have a different impact with other isiZulu-speaking learners from, for example, rural Kwa-Zulu Natal. Furthermore, as is typical of a Gauteng township setting, there are many different L1s in any class of learners. Many of the learners who selected the isiZulu-medium course were not L1 speakers of isiZulu. However, in discussion with these learners they noted that they understood isiZulu better than English. Other learners, particularly learners with Sotho-group L1s, did not have an equal opportunity to learn bilingually as they were not comfortable with isiZulu and would have preferred to learn bilingually through a Sotho language.

As is seemingly inevitable with many technological interventions, the technology element 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. We then ended up working on the videos once term had started. This resulted in us rushing to get the videos up in time, and giving us less room to review the videos in more detail before rolling them out in the experiment. Furthermore, it was difficult to review the experiment during the process of implementation because everyone involved in its review were active facilitators who had to be attending to learners' needs and queries throughout the session. There was very little space for passive observation and reflection.

It is important to contextualise the data while it is analysed. Given the demographics of Diepsloot, the learners all have very different language as well as mathematical proficiencies and motivation levels, and they have varying socio-economic and personal contexts, and these obviously play a large role in learners' achievement within the course. It is for reasons such as this that both quantitative and qualitative research methods were incorporated.

As the purpose of a design experiment is to implement theory in real-life situations, and then adapt and improve the design through numerous iterations, it is important that the experiment is revised and improved. Once the data has been analysed, recommendations will be made to inform further improvements to the design.

All Grade 7 learners at OLICO Youth began the Fractions course at the beginning of the third term, i.e. the third quarter of the academic year. There were eight lessons, and they were given five weeks in which they should finish the course. They were expected to attend two compulsory classes a week and complete one lesson a session, which would be two lessons a week. If they fell behind they will be expected to attend catch-up sessions. At the end of the course all learners wrote a checkpoint test. This test was written on paper and in English, to replicate the circumstances and LoLT of the learners' schools.

At the beginning of the term learners self-selected whether they would enrol in 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.

At the end of the second term, before the bilingual course began, all participants completed questionnaires (see fig. 61) about the videos they had been watching and the mathematics they had been doing at OLICO Youth for the first half of the year. The questionnaires included a Likert scale in which participants indicated the perceived level of difficulty of the videos and the mathematics. Thereafter they answered whether they would prefer to watch the videos in their home languages, and if they had any further comments about the videos. To further investigate learners' attitudes and experiences, and to better facilitate discussion with learners who may not have sufficient writing skills to convey their thoughts, focus group discussions were held. These discussions were facilitated by 16 Winter School volunteers with groups of four or five learners. The volunteers asked the group questions and then wrote down notes on the conversation that followed. Where possible, discussion was encouraged in whichever language the learners were most comfortable.

During the implementation of the bilingual course participant observation was conducted by the researcher, collaborating with other OLICO Youth facilitators. Frequent, small focus group discussions and informal interviews were conducted with the learners by the researcher and OLICO Youth facilitators in order to assess learners' attitudes toward the bilingual course and their experience thereof.

Once the bilingual course was complete a questionnaire similar to that used prior to the Fractions course was completed by the learners, and subsequent focus group discussions were held. The questionnaire sought to discover whether learners found the videos easier to understand and the mathematics easier in the bilingual course.

The English-medium videos for the Fractions course were created by the mathematics coordinator. I transcribed these videos and identified and colour-coded context-embedded and context-reduced elements of the video, in line with the translanguaging model developed in this research. The bilingual resource creator then reversioned the videos accordingly, including the video text where necessary, and recorded the videos in English and isiZulu using the video templates created by the mathematics coordinator. The videos were created using Explain Everything, an app available on iOS which allows the user to create learning videos. Once the videos had been created they were uploaded to our YouTube channel (https://www.youtube.com/user/olicoTV), after which they were imbedded in the OLICO Youth mathematics course.

Several layers of data were captured in order to analyse the videos: improvement in learners' pre- to post-quiz scores, number of post-quizzes attempted, improvement in post-quizzes, and a comparison of bilingual and control group scores. Learners' attendance and any known personal issues were also considered when analysing the data.

During the Fractions course the previous year I recorded which words the learners were unfamiliar with, and those have been included in the glossary along with other words I made informed guesses may be new or challenging to some learners. In the glossary I have written short contextual explanations of the words in English, and the bilingual resource creator has written short contextual explanations of the words in isiZulu. This glossary was uploaded onto the OLICO Youth mathematics course and is only available to the learners enrolled in the bilingual Fractions course. When a learner comes across one of these words, they may simply click on the word and be immediately provided with the English and isiZulu explanations. The glossary data to be analysed consists of which learners used the glossary, which terms they looked up, and how often each glossary term was clicked on.

3.3 Analysis

The different types of data collected for this research required different analyses to be made. Grounded theory, that is the synthesis of empirical findings with the application of relevant research in the field (Davis, 1995: 440), was used to analyse the qualitative data, using the analytical framework consisting of socio-political, linguistic, mathematical and personal elements. Effect size was calculated in order to confirm whether there had been any significant difference between the performance of the experimental and control groups on the pre- and post-tests. This accounts for the deviation of outlying scores within the groups, and will be discussed in greater detail in the data presentation chapter.

3.4 Ethics

3.4.1 Participant involvement

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 a few parents did not give permission for their children to take part in the experimental course. The permission form the parents signed can be found in Appendix D. 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.

As OLICO Youth is a NGO/NPO that provides supplementary academic support outside of the school curriculum, permission from the Department of Basic Education was not needed. Permission was granted by the staff of OLICO Youth through a verbal agreement. The proceedings of this experiment and research were also kept strictly in line with the values and conveniences of OLICO Youth, the organisation hosting this research. Care was taken not to disrupt normal proceedings at OLICO Youth any more than absolutely necessary. All the resources created by OLICO Youth are open source under the creative commons license BY-NC-SA and are free to share and distribute.

Permission for this research to be undertaken was granted by the Rhodes University Higher Degrees Committee.

3.4.2 Researcher's biases

It should be noted that I, the researcher, was actively involved in the theorisation and creation of the experiment as well as the analysis thereof. Furthermore the bilingual resource creator, who assisted me in creating the experiment, was also actively involved in the implementation of the experiment. This naturally adds an unavoidable degree of subjectivity of which I have been acutely aware.

3.5 Conclusion

This chapter has outlined DBR and its application to this research project. It is clearly an apt methodology as it accounts for the complexities of creating an experiment, implementing it and then evaluating it, all within a rather complex context. The methods in which this was done have been detailed. It has been clarified that ethical clearance was granted by all parties involved in this research, and the researcher's biases have been outlined. This chapter has thus explained what theory informed how the research was conducted and the different factors that were taking into consideration in this research project.

Chapter 4: Data Presentation

4.1 Introduction

This chapter will present the various data that were collected in this research project. The data was collected in order to answer the research questions, namely: how learners' L1s can be viably incorporated in learning; how the use of translanguaging in the online OLICO Youth mathematics course promoted learners' conceptual development; and how the use of translanguaging in the online OLICO Youth mathematics course affected learners' attitudes to learning.

The raw data that was collected has been organised and connections have been made in order to present data that gives an immediate idea of the results. Relevant trends have been illustrated and noted, and any anomalies have been identified and pointed out. This chapter will present both quantitative and qualitative findings relating to learners' conceptual understanding and attitudes toward language.

This chapter will begin with the quantitative presentations of the learners' pre-quiz to post-quiz improvement in the Fractions course and their usage and retention of the glossary. This data was collected by accessing the back-end of the Moodle where the programme had stored all of the learners' pre- and post-quiz scores and clicks on the hyperlinked glossary. Thereafter the supporting factors will be presented in the form of qualitative results from discussions and surveys with parents and learners. The longer-term impact of the course will then be presented through the qualitative presentation of surveys and discussions conducted with the learners. The data from the discussion groups was collected by holding discussions and taking annotative notes, and the data from the surveys was collected by distributing and collecting written surveys from the learners.

4.2 Research participants

Several people were involved in the data collection. The data was primarily collected by myself, and I was assisted by the bilingual resource creator and the other OLICO Youth online mathematics course facilitators, the OLICO Youth Winter School volunteers, the mathematics coordinator, and the project co-founder.

The OLICO Youth learners constituted the research participants. There were 40 participating learners in total, 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[6]; five learners whose L1 is isiXhosa; and one learner whose home language is Xistonga. 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.

4.3 Pre-quiz to Post-quiz improvement in Fractions course

All learners completed an online pre-quiz at the beginning of each lesson. This started off with 40 learners completing the Fractions 1 pre-quiz, but this number grew smaller as the lessons progressed and some learners fell behind. Learners who did not attend their sessions regularly or who struggled with the concepts took longer to complete lessons and as a result did not go through all of the lessons before they wrote the checkpoint at the end of the Fractions section. The pre-quiz is an online short quiz of roughly six questions on the lesson topic, which determines whether or not the learner has sufficient understanding of the topic (see figs. 5 and 6 in Chapter 1). Learners who attained less than 80% for the pre-quiz, indicating they do not have sufficient understanding of the topic, would then watch the video. Those who attained 80% or more, indicating they understood the topic, automatically progressed to the mixed practice. The number of learners from both the experimental and control groups who attained 80% or more for a lesson and thus did not write the post-quiz is illustrated in the graph below, together with the number of learners who attained less than 80% for the pre-quiz and thus watched the video and wrote the post-quiz. The number of learners who achieved above or below 80% for the pre-quizzes is illustrated in fig. 25.

[6] Sesotho, Sepedi and Setswana are grouped together here as they are mutually intelligible with each other but not with isiZulu.

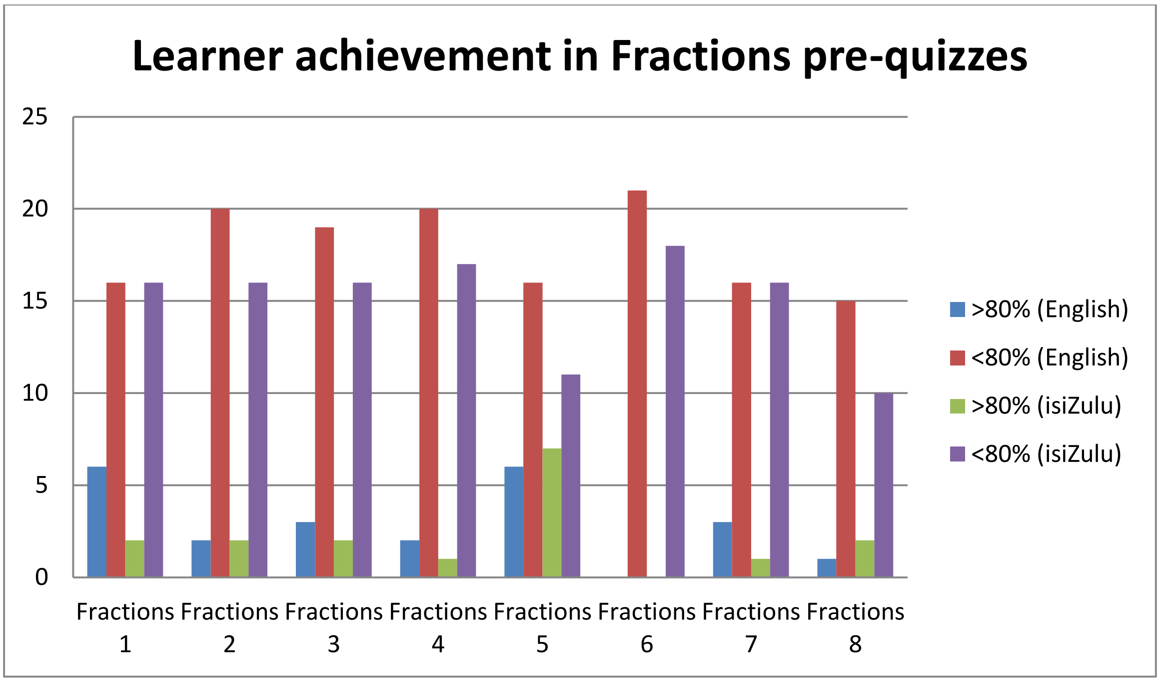


Figure 25: Learner achievement in Fractions pre-quizzes

Learners who watch the video then attempted the post-quiz after the video. The post-quiz (see figs. 9 and 10 in Chapter 1) 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 mixed practice. If learners attain less than 80% they may attempt the quiz again until they attain 80%. The mixed practice (see figs. 11 and 12 in Chapter 1) then provides revision of other lesson topics to ensure learners consistently work with both new and previously learnt concepts. Learners should then attain a minimum of 60% for the mixed practice in order to continue to the pre-quiz of the next lesson. Each of these quizzes is completed online by the learners, and their results are captured in the Moodle programme.

In determining the improvement learners showed after watching the video, learners who achieved 80% or more for the pre-quiz and thus did not write the post-quiz were not included. Instead, only the results of the learners who achieved less than 80% for the pre-quiz and thus wrote the post-quiz were included. Even though learners could make several attempts at the post-quiz until they achieved 80% or more, only the first attempts of the post-quiz were included when calculating learners' improvement. This is because these results best reflect learners' understanding of the video. Most learners typically did not achieve 80% or more on their first attempt at the post-quiz; instead, learners generally achieved higher marks on subsequent attempts at the post-quiz. This is to be expected, as in subsequent attempts learners not only had the knowledge they gained from watching the video, but they had also built on this knowledge through practicing these skills in the post-quizzes they did before achieving 80% or more. The first attempts of the post-quiz were thus chosen and contrasted with the pre-quiz scores to represent the knowledge gained by watching the video (rather than the knowledge gained through practice).

The pre-quiz to post-quiz improvement is illustrated in the graphs later in this chapter. Each graph is accompanied by a written account of the data represented, the effect size of this difference, and an explanation of the effect size. Effect size is used in the fields of education and social sciences to ascertain the quantitative differences in an evaluation (Coe, 2002). This is done by finding the difference in achievement between the experimental and control groups, as well as the variation in achievement within these groups (Coe, 2002). This is important because it illustrates the overall improvement. For example, if there were 10 learners in a control group and 10 learners in an experimental group, and the groups showed averages of 10% and 15% improvement in a test respectively, the 5% point would appear to be quite a notable difference. However, if all learners showed 10% and 15% improvement in their tests respectively this would mean something quite different to if half the learners in the control group showed 5% improvement and the other half of the learners in the control group showed 15% improvement, even though this would still be 10% average improvement. By taking possibilities such as these into account mathematically, effect size can meaningfully show the difference in learners' improvement in the OLICO Youth online mathematics course. The effect size was determined through the following calculation:

$$\text{Effect size} = \frac{mean\ of\ experimental\ group - mean\ of\ control\ group}{pooled\ standard\ deviation}$$

Equation 1: Effect size

This calculation was done as follows: The means of the pre-quiz to post-quiz improvement of the experimental group (i.e. the group that completed the isiZulu-English bilingual online Fractions course) and the control group (i.e. the group that completed the English-medium online Fractions course) were calculated. The difference between these two means was calculated and then divided by the pooled standard deviation (SD). SD shows by how much the results differ on average from the mean. The pooled SD was found by calculating the SD of both the experimental and control groups together, which was done using the SD population formula in Microsoft Excel. The result would then be a number which was used to contextualise this difference in effect, as illustrated in the table below. Note that the table reflects only a portion of possible effect sizes.

Effect Size	Percentage of control group who would be below average person in experimental group	Rank of person in a control group of 25 who would be equivalent to the average person in experimental group	Probability that you could guess which group a person was in from knowledge of their 'score'.	Equivalent correlation, *r* (=Difference in percentage 'successful' in each of the two groups, BESD)	Probability that person from experimental group will be higher than person from control, if both chosen at random (=CLES)
0.0	50%	13th	0.50	0.00	0.50
0.1	54%	12th	0.52	0.05	0.53
0.2	58%	11th	0.54	0.10	0.56
0.3	62%	10th	0.56	0.15	0.58
0.4	66%	9th	0.58	0.20	0.61
0.5	69%	8th	0.60	0.24	0.64
0.6	73%	7th	0.62	0.29	0.66

Table 2: Effect size contextualisation

(Coe, 2002)

4.3.1 Fractions Lesson 1: Introduction to Fractions

Fractions Lesson 1 (see figs. 26 and 27) provided an introduction to fractions. The lesson covered what a fraction is, and what the names of fractions indicate: for example $\frac{1}{3}$ means that there is a whole that has been cut into three pieces and this fraction represents one of those pieces.

Figure 26: Fractions Lesson 1 video (English)

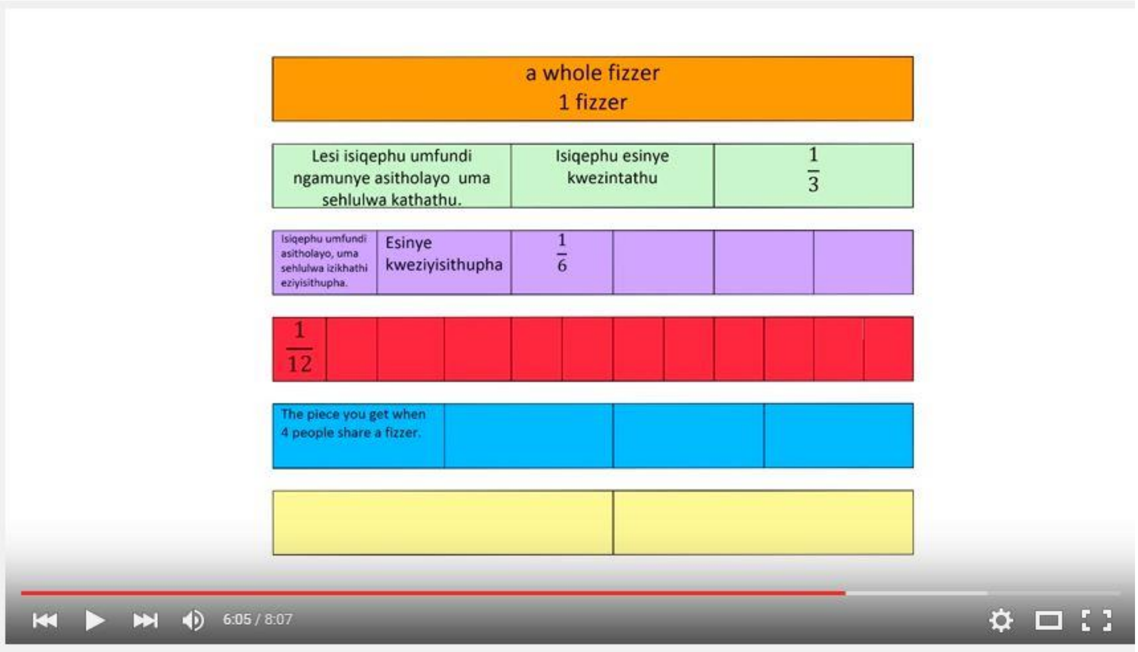


Figure 27: Fractions Lesson 1 video (English-isiZulu bilingual)

This lesson was completed by 16 learners in the control group and 16 learners in the experimental group. The learners in the control group watched the videos in English and did not have access to the bilingual hyperlinked online glossary or the printed homework book bilingual glossary. The learners in the experimental group watched the videos that had been created bilingually in isiZulu and English, and had access to both the hyperlinked online bilingual glossary and the printed homework book bilingual glossary. Below is an excerpt of what learners were asked in the pre-quiz and post-quiz. The quizzes for the experimental and control groups were identical, with the exception of the hyperlinked glossary being included in the experimental group's quizzes.

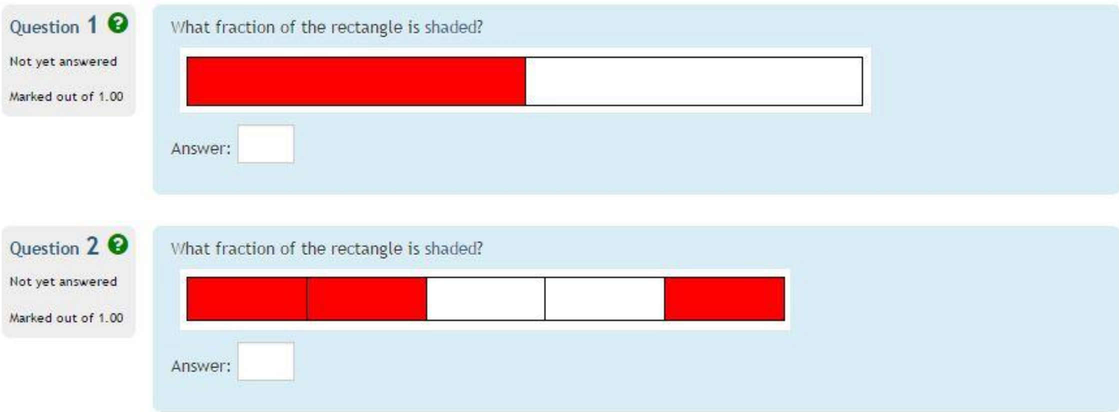


Figure 28: Fractions Lesson 1 questions

The control group scored an average of 52.5% for the pre-quiz and 60.63% for the post-quiz, showing an improvement of 8.13 percentage points. The SD of this group's improvement is 15.09. The experimental group scored an average of 47.5% for the pre-quiz and 65% for the post-quiz, showing an improvement of 17.5 percentage points. The SD of this group's improvement is 21.94. These improvements are illustrated in the graph below.

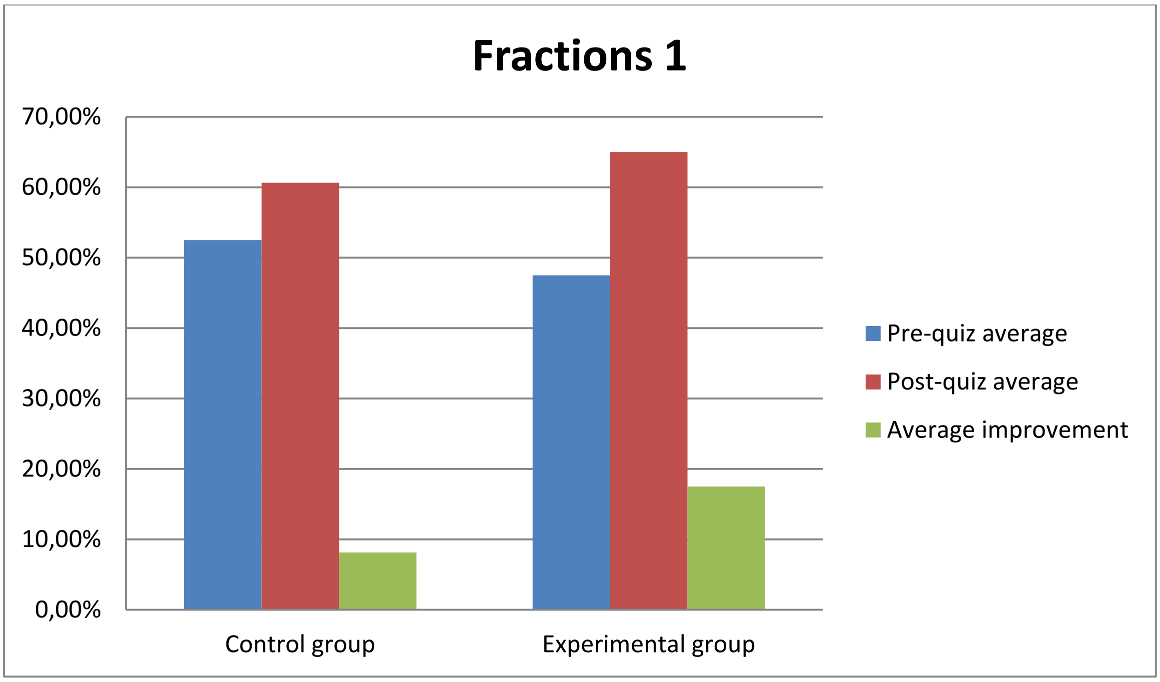


Figure 29: Fractions Lesson 1 improvement

The pooled SD is 18.83, and the effect size is 0.5. This means that 69% of the control group would have shown less improvement than the middlemost-scoring learner[7] in the experimental group.

It is interesting to note that there is significantly more improvement in the experimental group in the first lesson of this experiment. It is also noteworthy that the experimental group had a lower average pre-quiz score and a higher average post-quiz score than the control group. This and other such points raised throughout this chapter will be discussed in greater detail in the following chapter on data analysis.

4.3.2 Fractions Lesson 2: Comparing Fractions

Fractions Lesson 2 (see figs. 30 and 31) explained how to identify the difference in size between fractions with different denominators. This dealt with the common misconception that, for example, $\frac{1}{2}$ is smaller than $\frac{1}{4}$ because 2 is smaller than 4. In these videos learners are encouraged to graphically represent the fractions in order to see which fractions are bigger or smaller. In answering the questions the learners made use of the Geogebra plugin (which can

[7] This is the learner whose improvement was the median score, that is, the score in the middle. For example if five learners showed improvements of 2%, 4%, 6%, 10%, and 14%, the middlemost-scoring learner would be the learner who showed 6% improvement.

be found at www.geogebra.org). The facilitators explained how the learners should use the Geogebra plugin during the session times.

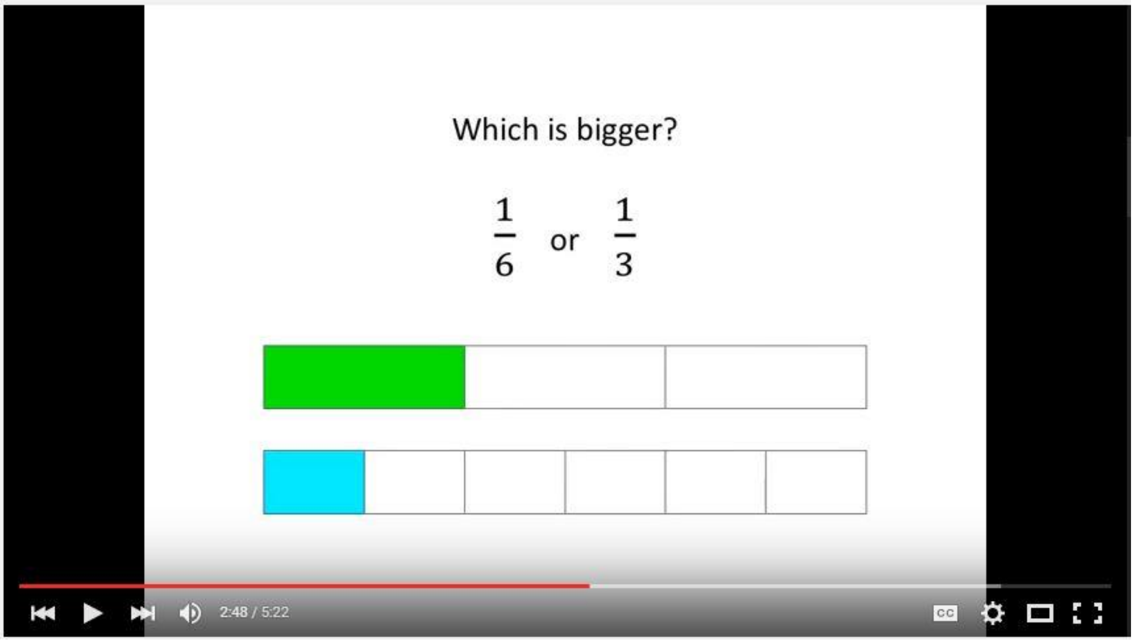


Figure 30: Fractions Lesson 2 video (English)

Figure 31: Fractions Lesson 2 video (English-isiZulu bilingual)

Fractions Lesson 2 was completed by 20 learners in the control group and 16 learners in the experimental group. Again, both groups completed almost identical courses in English, with the exception being that the English-isiZulu bilingual experimental group watched the videos in English and isiZulu and had access to the online and homework book glossaries. This was the case for all the lessons in the Fractions course. Below is an excerpt of what learners were asked in the pre-quiz and post-quiz. The learners could select <, > or *equal to* from the drop-down menu, and the Geogebra plugin pictured below allows learners to slide the dots to graphically represent the fractions in the rectangular blocks.

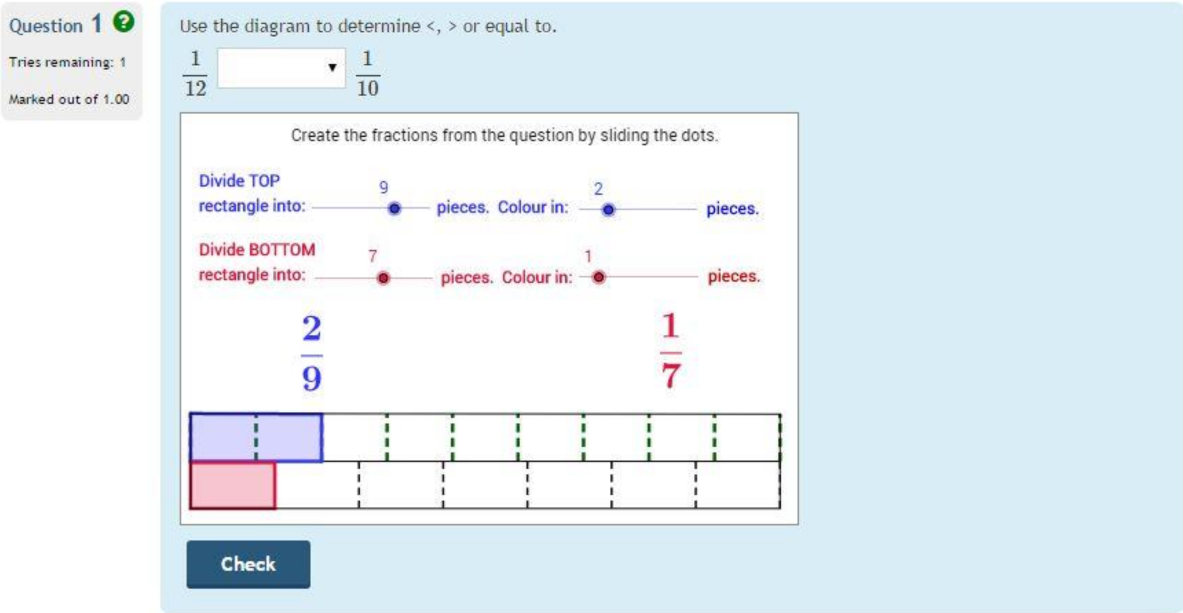


Figure 32: Fractions Lesson 2 questions

The control group scored an average of 40.83% for the pre-quiz and 56.67% for the post-quiz, showing an improvement of 8.13 percentage points. The SD of this group's improvement is 15.83. The experimental group scored an average of 43.75% for the pre-quiz and 61.46% for the post-quiz, showing an improvement of 17.71 percentage points. The SD of this group's improvement is 22.41. These improvements are illustrated in the following graph:

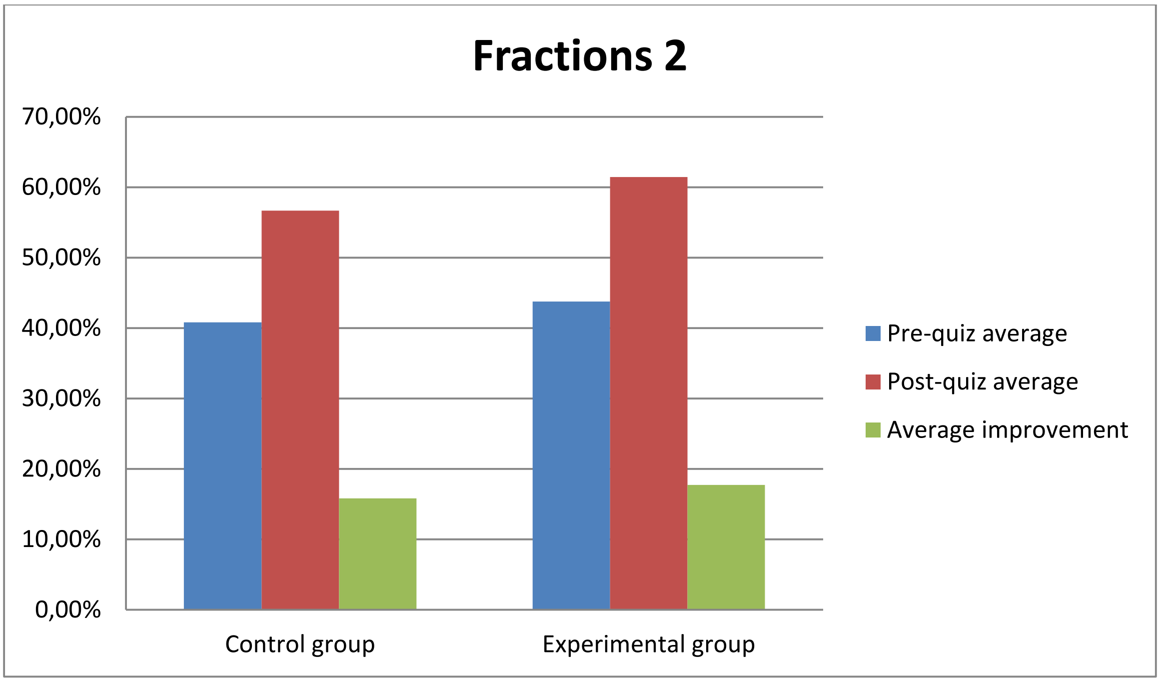


Figure 33: Fractions Lesson 2 improvement

The pooled SD is 24.21, and the effect size is 0.08. Although the learners in the experimental group showed greater improvement, this effect size is too small from which to draw any meaningful conclusions.

4.3.3 Fractions Lesson 3: Equivalent fractions

Fractions Lesson 3 (see figs. 34, 35 and 36) discussed the meaning of the word 'equivalent', emphasising that equivalent fractions might look different to each other but actually have the same value and represent the same quantity. The video explained how to create equivalent fractions by multiplying or dividing fractions. The following screenshots are taken from the English-medium and English-isiZulu bilingual videos respectively; note that the third screenshot is taken from the English-medium video but was the same for the English-isiZulu bilingual video as that section of the video is visually represented by diagrams and numbers, rather than words.

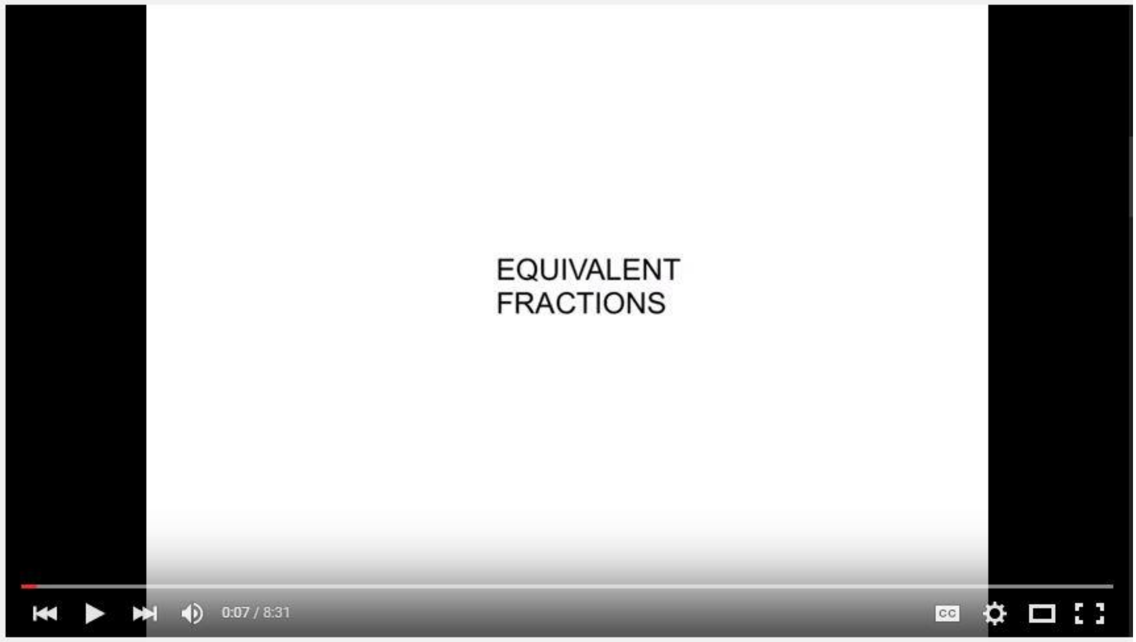


Figure 34: Fractions Lesson 3 video (English)

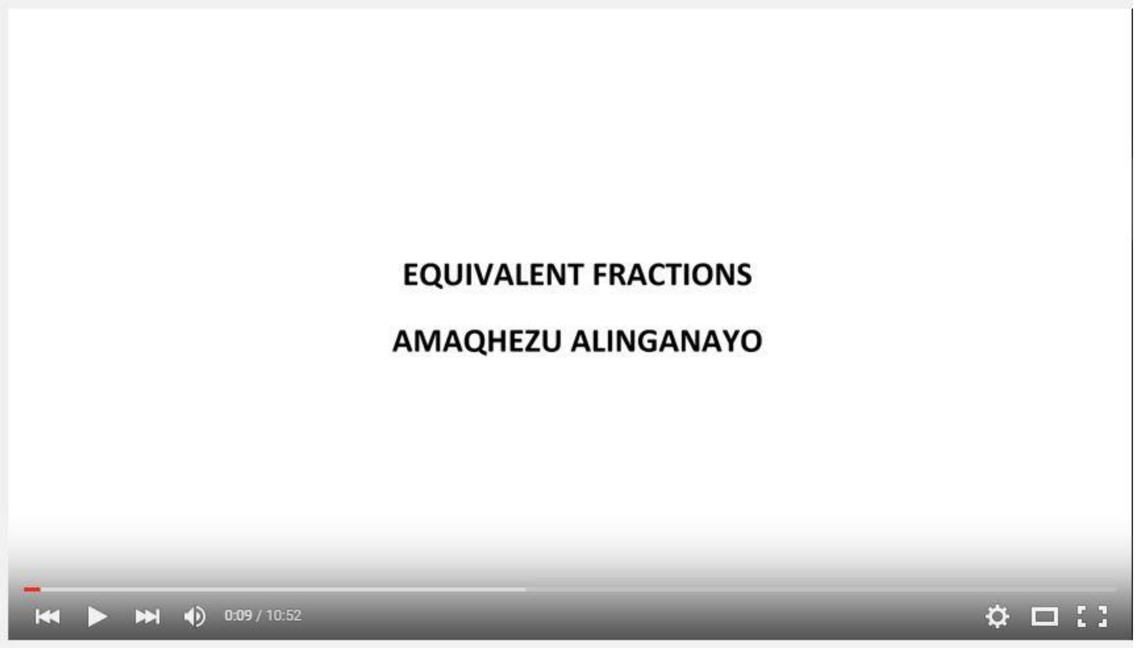


Figure 35: Fractions Lesson 3 video (English-isiZulu bilingual)

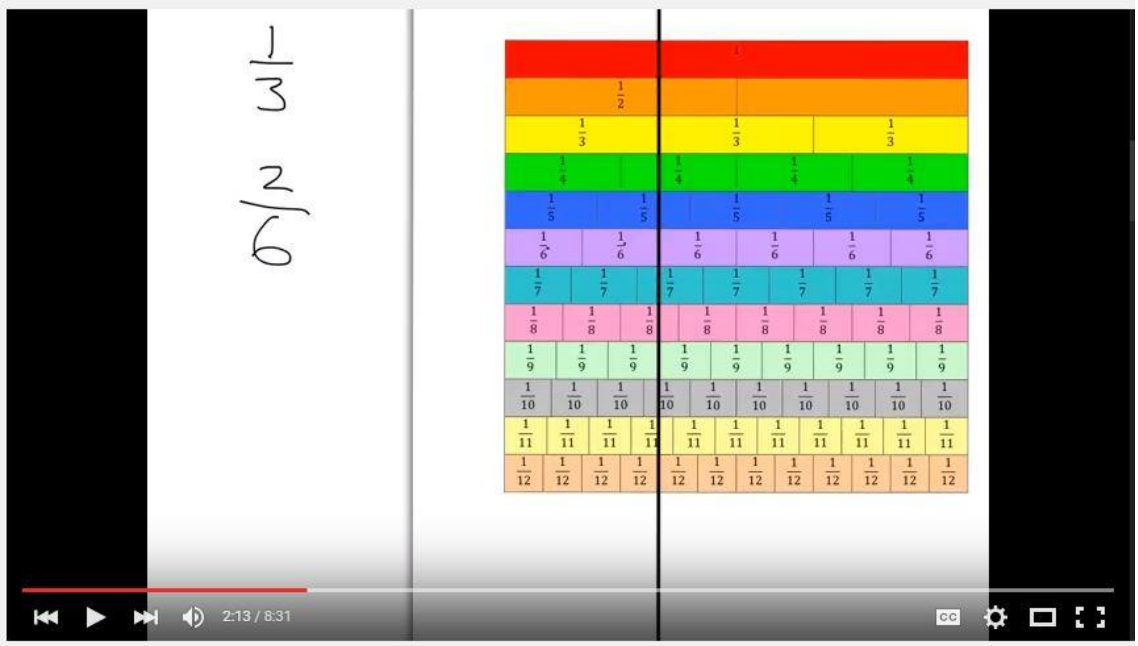
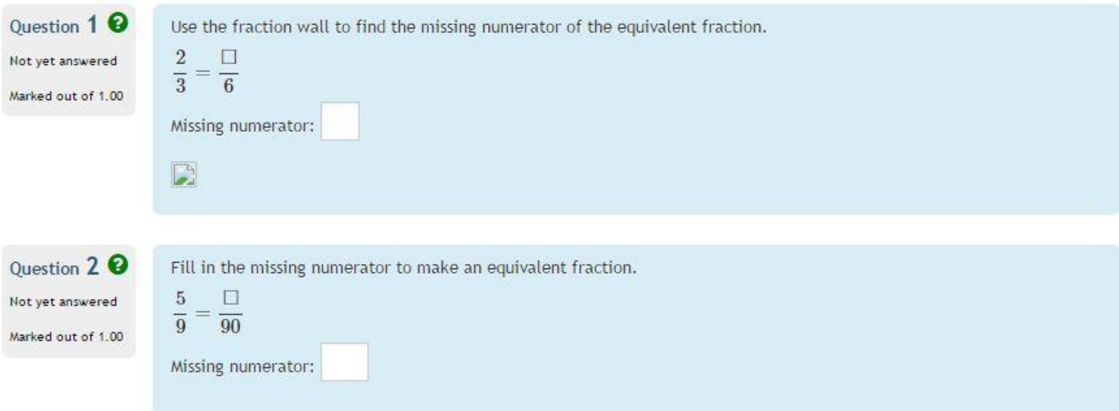


Figure 36: Fractions Lesson 3 video (English and English-isiZulu bilingual)

Fractions Lesson 3 was completed by 19 learners in the control group and 16 learners in the experimental group. The following is an example of the questions the learners were asked in the pre- and post-quizzes:


Question 1
Not yet answered
Marked out of 1.00

Use the fraction wall to find the missing numerator of the equivalent fraction.

$\frac{2}{3} = \frac{\square}{6}$

Missing numerator:

Question 2
Not yet answered
Marked out of 1.00

Fill in the missing numerator to make an equivalent fraction.

$\frac{5}{9} = \frac{\square}{90}$

Missing numerator:

Figure 37: Fractions Lesson 3 questions

The control group scored an average of 28.07% for the pre-quiz and 44.52% for the post-quiz, showing an improvement of 16.45 percentage points. The SD of this group's improvement is 27.22. The experimental group scored an average of 44.79% for the pre-quiz and 58.85% for the post-quiz, showing an improvement of 14.06 percentage points. The SD of this group's improvement is 26.76. These improvements are illustrated in the following graph:

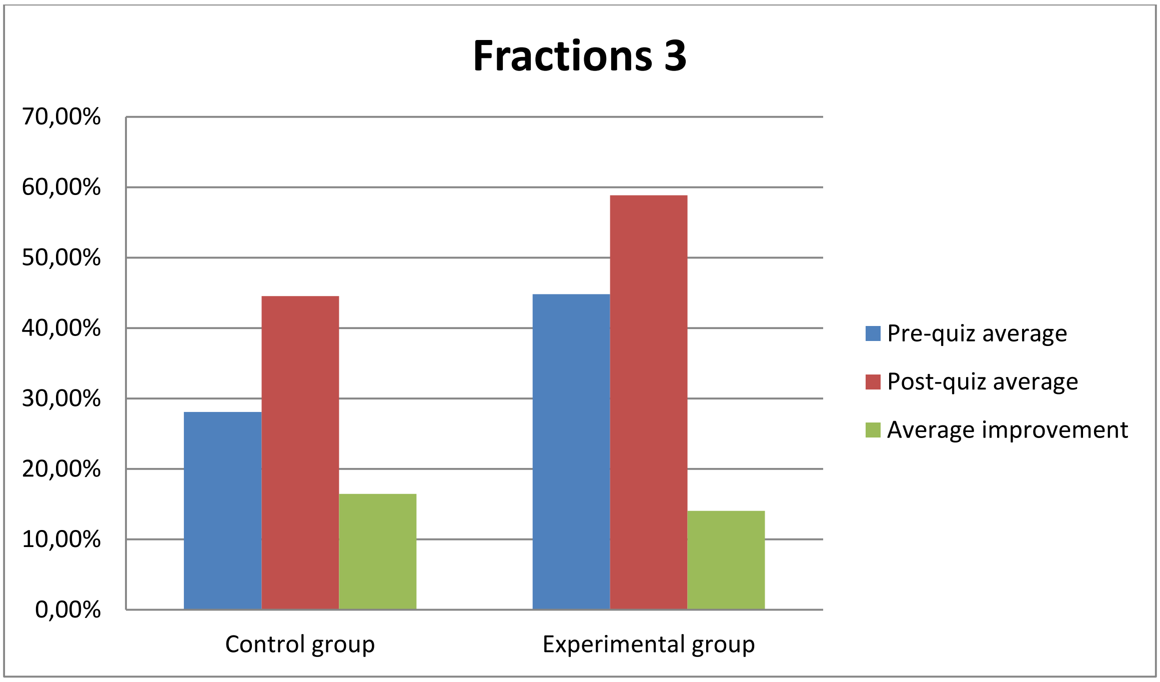


Figure 38: Fractions Lesson 3 improvement

The pooled SD is 27.01, and the effect size is -0.09. Although the learners in the control group showed greater improvement, this effect size is too small from which to draw any meaningful conclusions. It is interesting to note, however, that the experimental group had significantly higher scores for the pre-quiz and post-quiz than the control group. This will be explained in greater detail in the data analysis chapter.

4.3.4 Fractions Lesson 4: Improper fractions to mixed numbers

Fractions Lesson 4 (see figs. 39 and 40) explained that an improper fraction is the name given to a fraction where the numerator is bigger than the denominator. This was illustrated such that learners should understand that improper fractions are bigger than a whole. The videos encouraged learners to first depict the improper fraction graphically, and then to determine what a given improper fraction would be as a whole number.

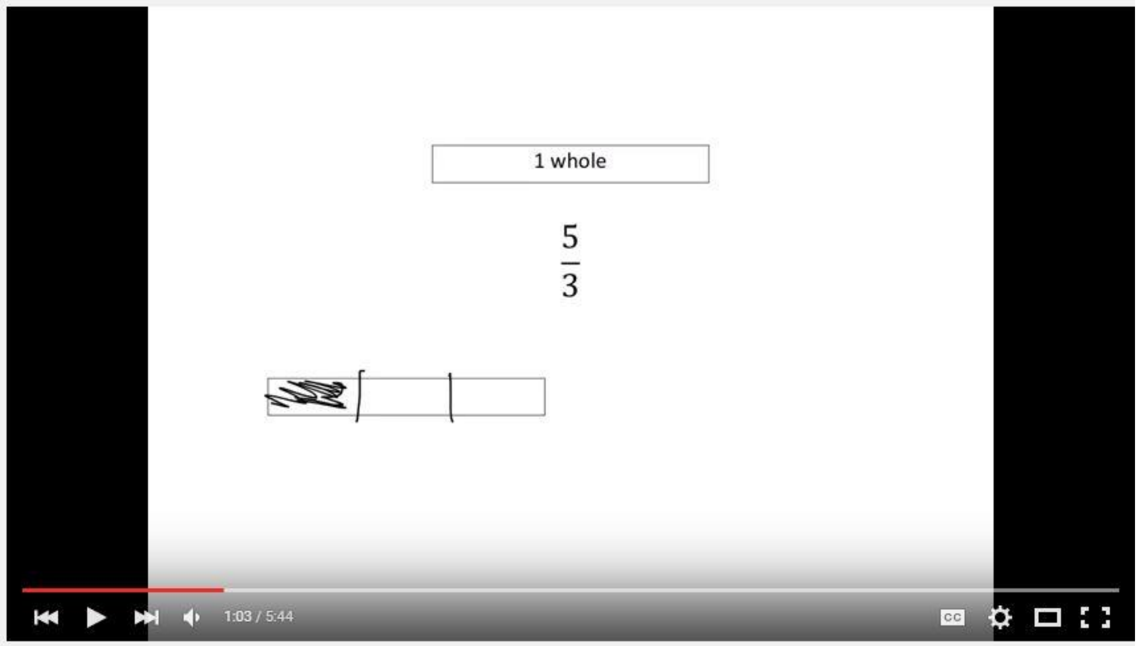


Figure 39: Fractions Lesson 4 video (English)

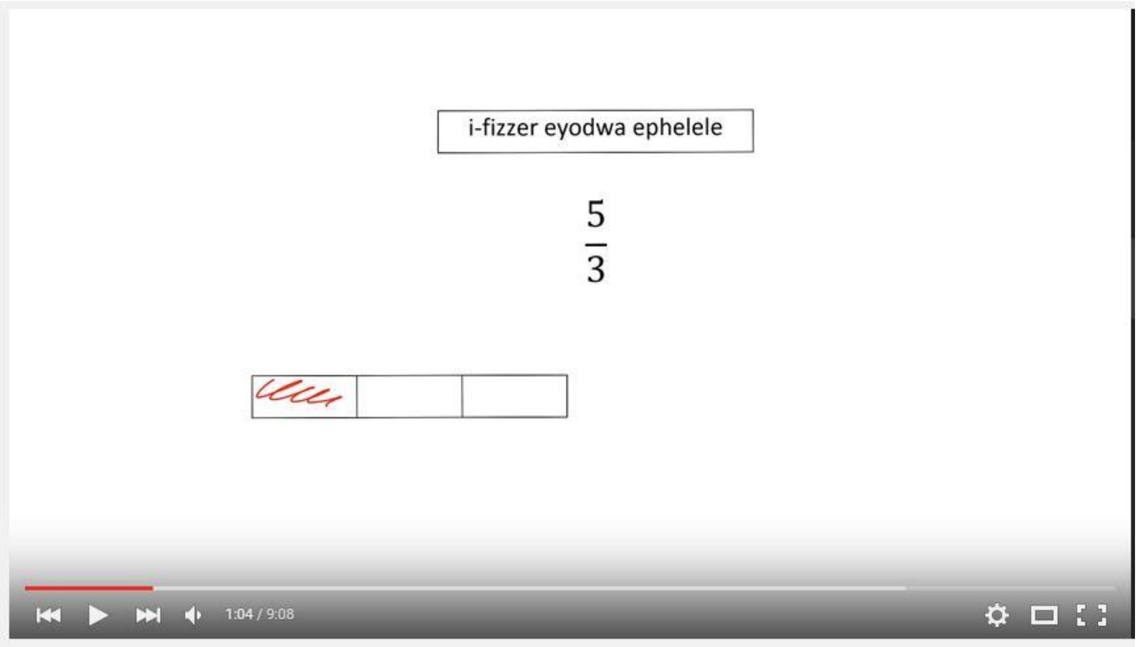


Figure 40: Fractions Lesson 4 video (English-isiZulu bilingual)

Fractions Lesson 4 was completed by 20 learners in the control group and 17 learners in the experimental group. The following is an example of what sort of questions the learners were expected to answer in the pre- and post-quizzes:

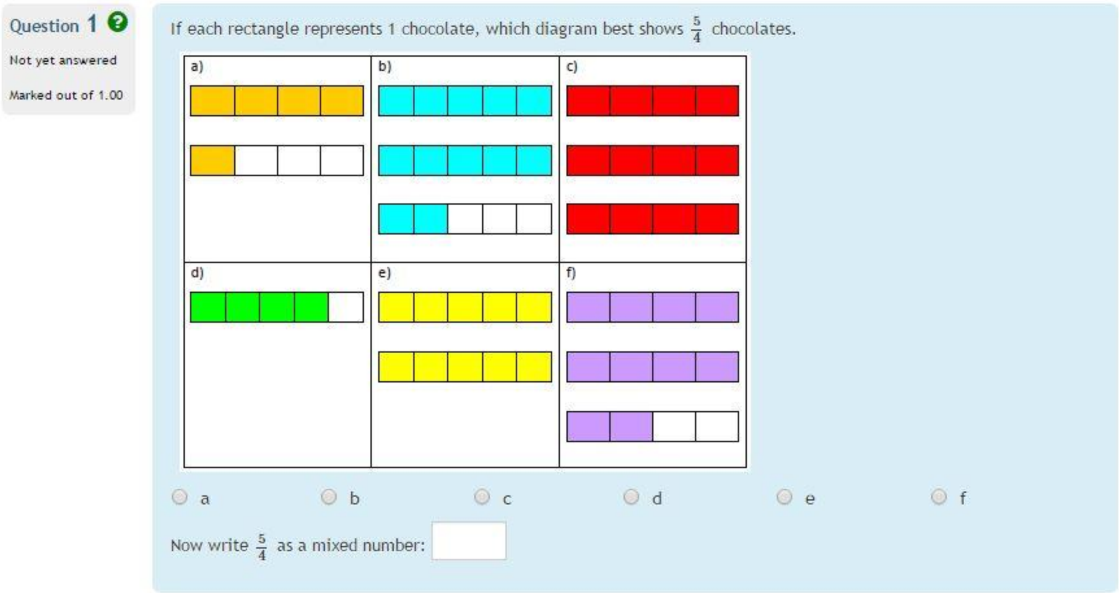


Figure 41: Fractions Lesson 4 questions

The control group scored an average of 10.83% for the pre-quiz and 32.08% for the post-quiz, showing an improvement of 21.25 percentage points. The SD of this group's improvement is 29.49. The experimental group scored an average of 25% for the pre-quiz and 53.19% for the post-quiz, showing an improvement of 21.25 percentage points. The SD of this group's improvement is 30.27. These improvements are illustrated in the graph below.

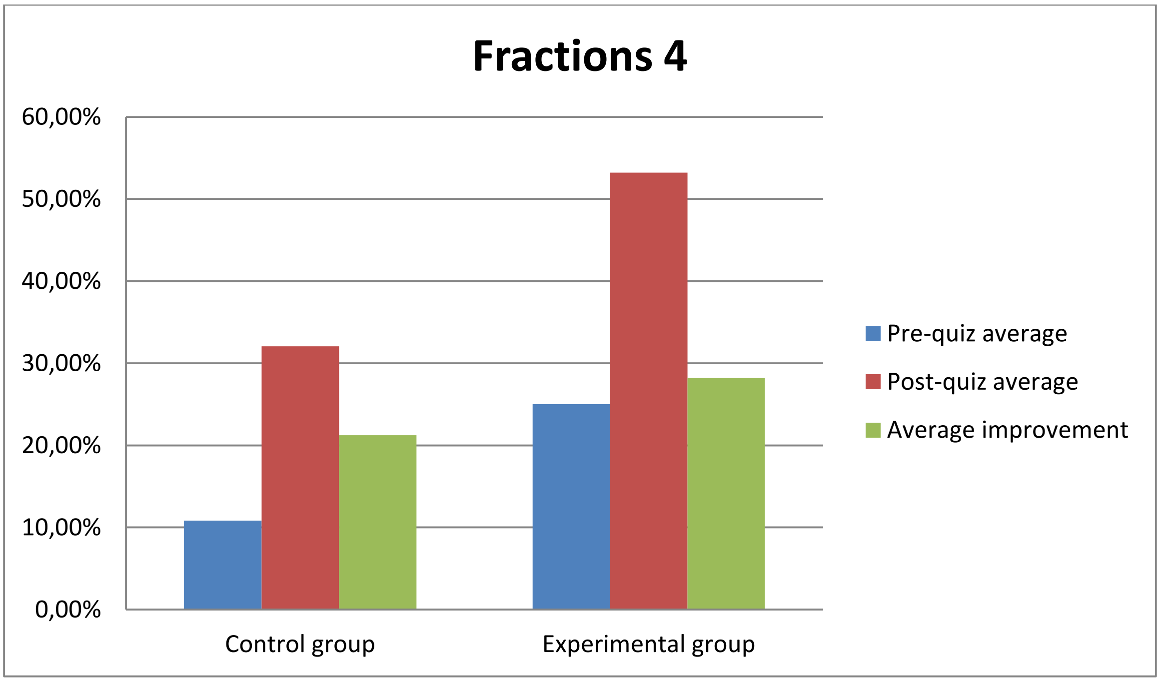


Figure 42: Fractions Lesson 4 improvement

The pooled SD is 29.71, and the effect size is 0.23. Rounding the effect size off to 0.2, this means that 58% of the control group would have shown less improvement than the middlemost-scoring learner in the experimental group. It is interesting to note here again that the experimental group completed the pre-quiz and post-quiz with significantly higher averages than the control group. This will be discussed in greater detail in the data analysis chapter.

4.3.5 Fractions Lesson 5: Mixed numbers to improper fractions

Fractions Lesson 5 (see figs. 43 and 44) explained that each whole can also be represented by a fraction, and so if there is a mixed number the whole numbers can be represented by fractions and added to the existing fraction. Once this concept had been explained by using graphic representations and encouraging learners to do the same, the mathematical processes that can be followed were explained. This aimed to give learners the conceptual understanding through the graphic illustrations and procedural fluency through explaining the mathematical processes. Extracts from the videos are presented below.

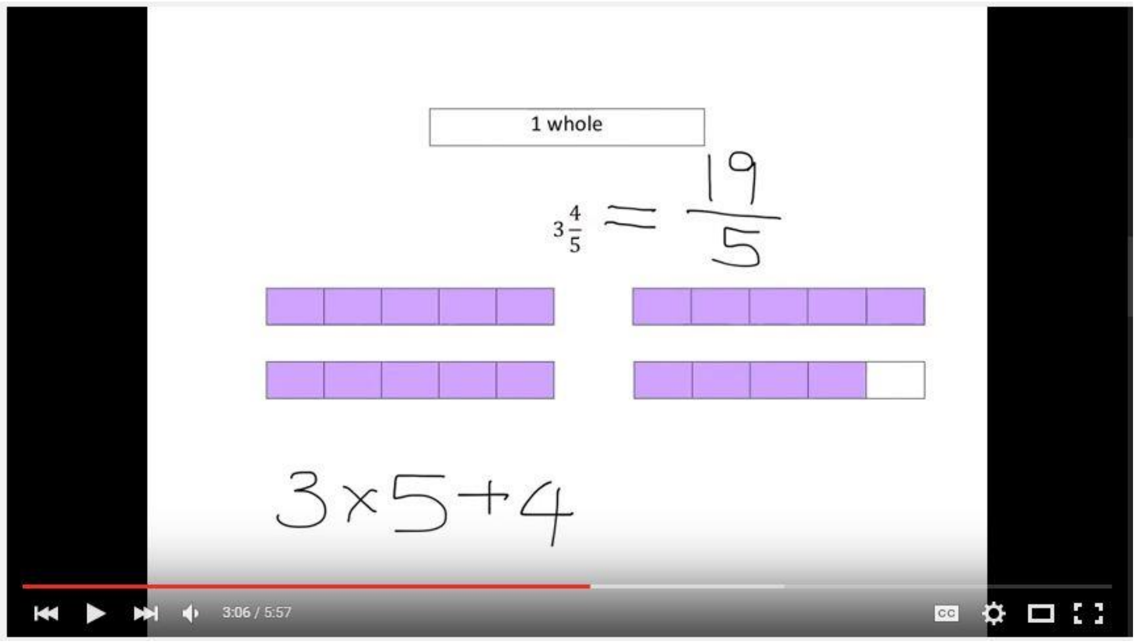


Figure 43: Fractions Lesson 5 video (English)

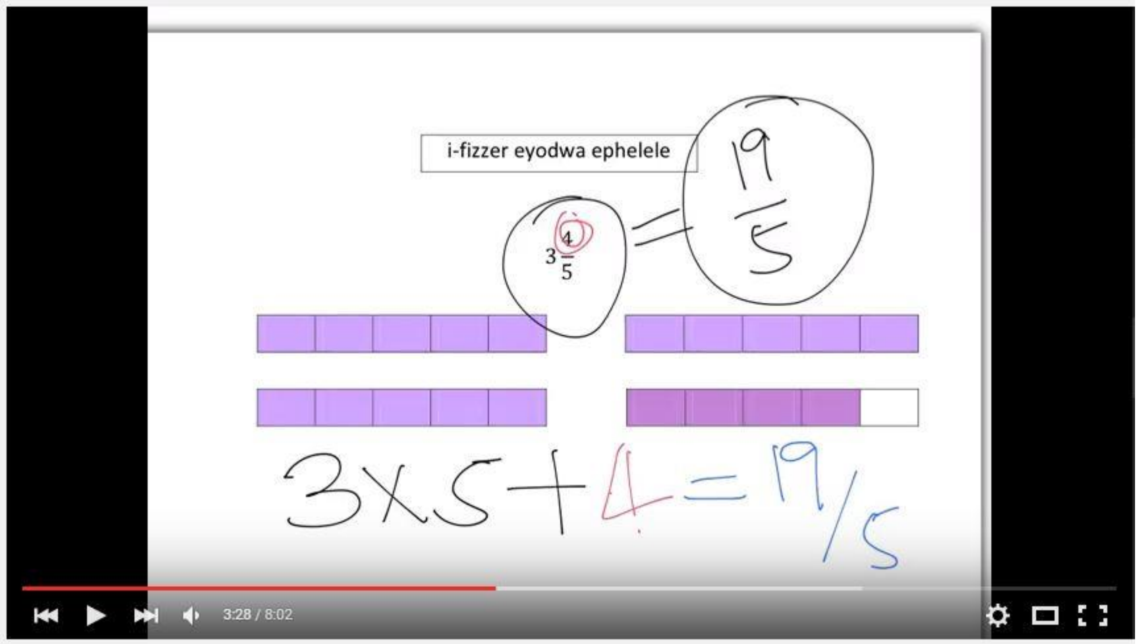


Figure 44: Fractions Lesson 5 video (English-isiZulu bilingual)

Fractions Lesson 5 was completed by 16 learners in the control group and 11 learners in the experimental group. The following is an example of the questions learners were expected to answer in the pre- and post-quizzes:

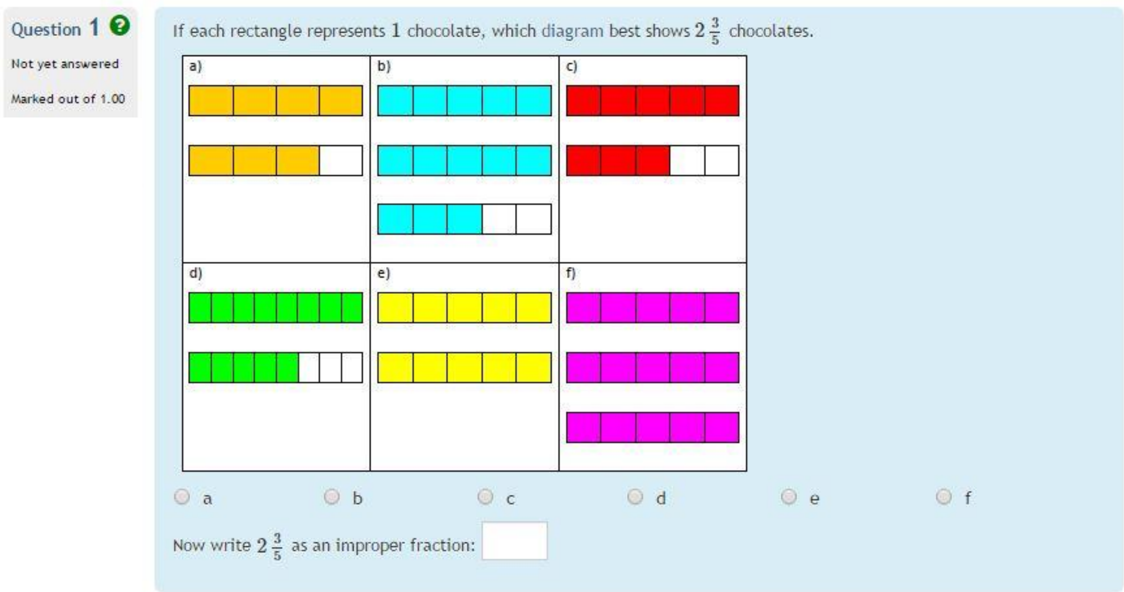


Figure 45: Fractions Lesson 5 questions

The English-medium group scored an average of 21.36% for the pre-quiz and 62.24% for the post-quiz, showing an improvement of 40.89 percentage points. The SD of this group's improvement is 37.25. The English-isiZulu bilingual group scored an average of 16.67% for the pre-quiz and 56.06% for the post-quiz, showing an improvement of 39.40

percentage points. The SD of this group's improvement is 34.33. These improvements are illustrated in the graph below:

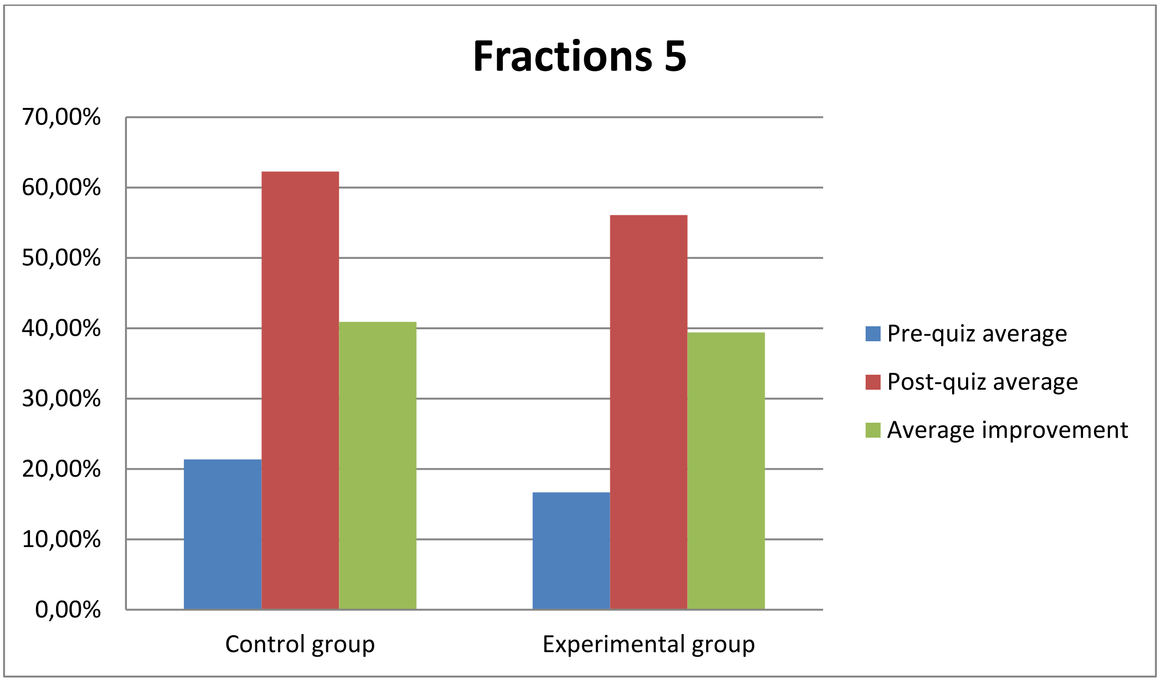


Figure 46: Fractions Lesson 5 improvement

The pooled SD is 36.11, and the effect size is -0.04. Although the learners in the English-medium group showed greater improvement, this effect size is too small from which to draw any meaningful conclusions. It is interesting that in this lesson the learners in the control group had higher average results for the pre-quiz and the post-quiz. However the difference between theirs and the results of the experimental group were minimal and also too small from which to draw meaningful conclusions.

4.3.6 Fractions Lesson 6: Adding and subtracting fractions with the same denominator

Fractions Lesson 6 (see figs. 47 and 48) began by visually illustrating how to add or subtract fractions with the same denominator. Once this had been clarified, it was then explained that in order to add or subtract mixed numbers with the same denominator, the mixed numbers should first be converted into improper fractions. The visuals for these videos consisted of numbers and images, and so the videos looked the same; however, the English-isiZulu bilingual videos still made use of codeswitching in the spoken parts of the video.

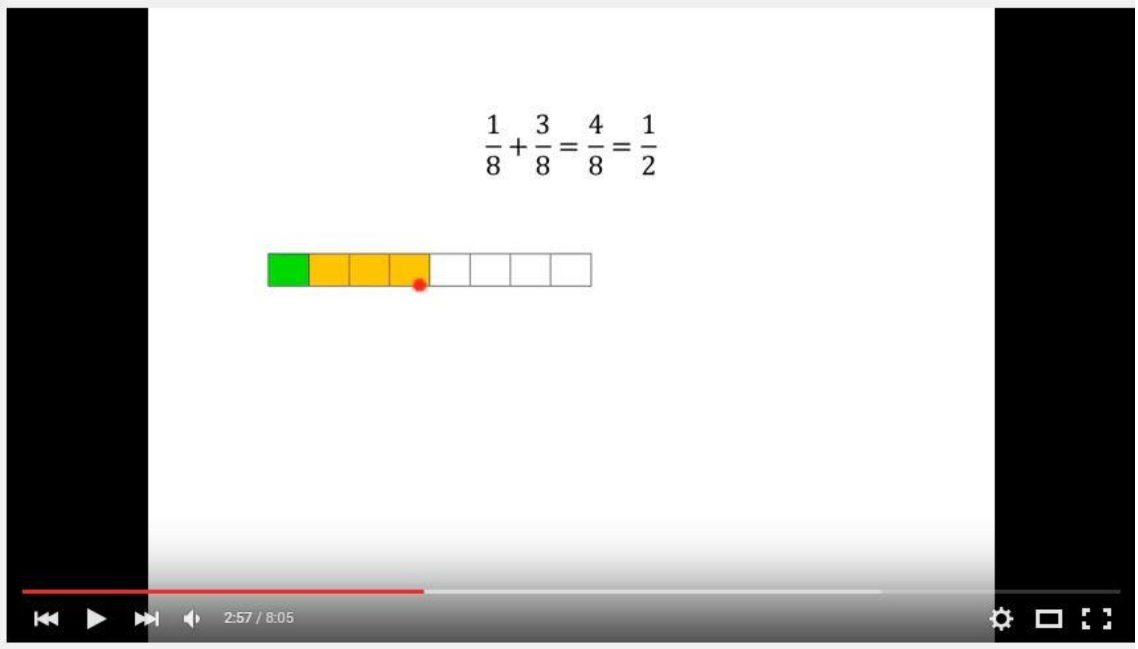


Figure 47: Fractions Lesson 6 video (English and English-isiZulu bilingual)

Fractions Lesson 6 was completed by 21 learners in the control group and 17 learners in the experimental group. The following is an example of the type of questions learners were expected to answer in the pre- and post-quizzes. Once again learners were encouraged to make use of the Geogebra plugin to visually represent the problem and to assist them in calculating their answers.

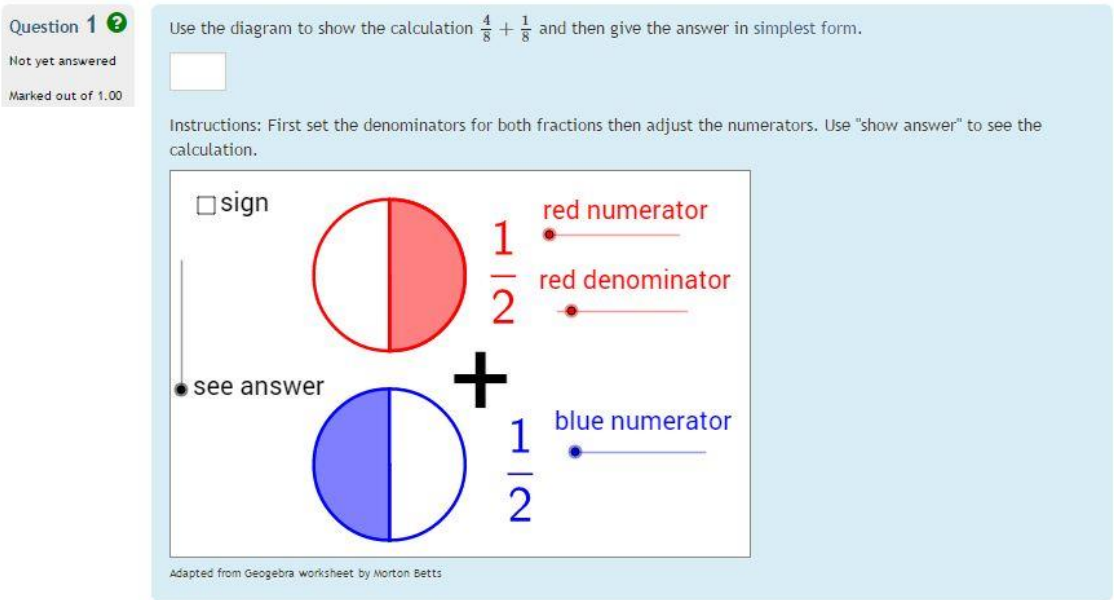


Figure 48: Fractions Lesson 6 questions

The control group scored an average of 21.43% for the pre-quiz and 47.84% for the post-quiz, showing an improvement of 26.41 percentage points. The SD of this group's improvement is 26.57. The experimental group scored an average of 37.25% for the pre-quiz and 50.76% for the post-quiz, showing an improvement of 13.5 percentage points. The SD of this group's improvement is 28.86. These improvements are illustrated in the graph below.

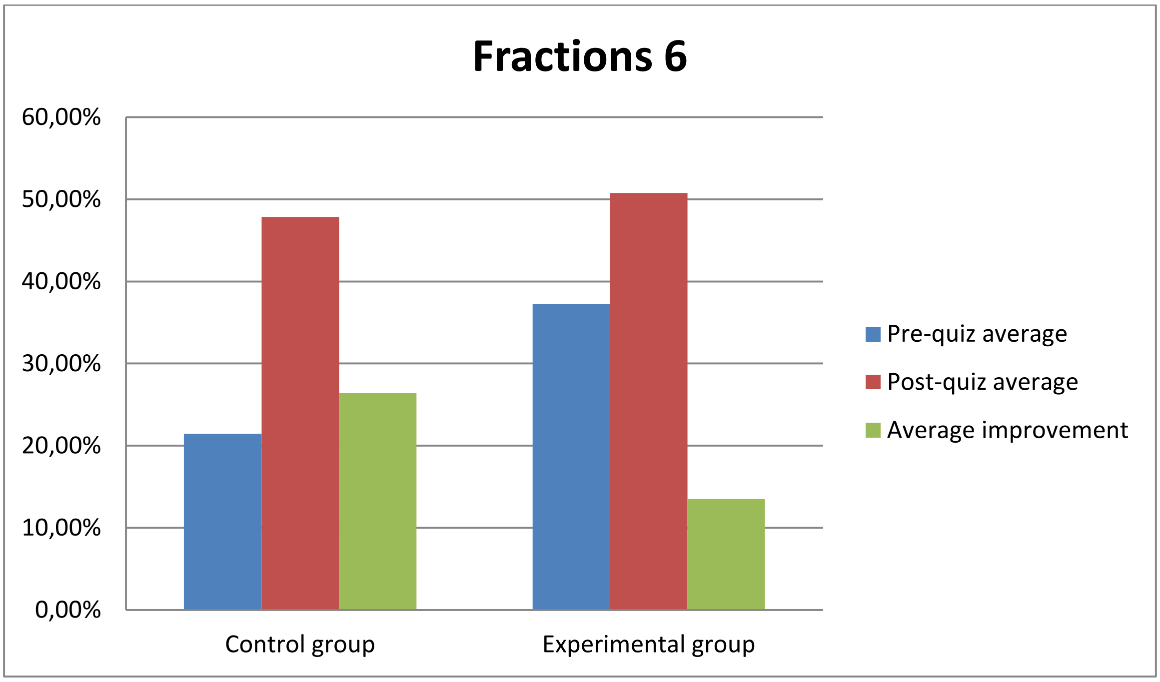


Figure 49: Fractions Lesson 6 improvement

The pooled SD is 27.61, and the effect size is -0.47. Rounded off to an effect size of -0.5, this means that 69% of the English-isiZulu bilingual group would have shown less improvement than the mean/middlemost-scoring learner in the English-medium group. It is interesting to note here that the control group started with a significantly lower pre-quiz average than the experimental group, but both groups attained similar post-quiz averages. This will be discussed in greater detail in the data analysis chapter.

4.3.7 Fractions Lesson 7: Adding fractions with different denominators

Fractions Lesson 7 (see figs. 50 and 51) began by revising equivalent fractions. The video then explained that in order to add fractions with different denominators one should first create equivalent fractions so that all the fractions have the same denominator, noting that the same applies if one is subtracting fractions with different denominators. The video then explained that if one is adding or subtracting mixed numbers with different denominators, one should again first convert the mixed numbers into improper fractions, after which one should find the lowest common denominator and add or subtract the numerators. The following are snapshots from the English-medium and English-isiZulu bilingual videos:

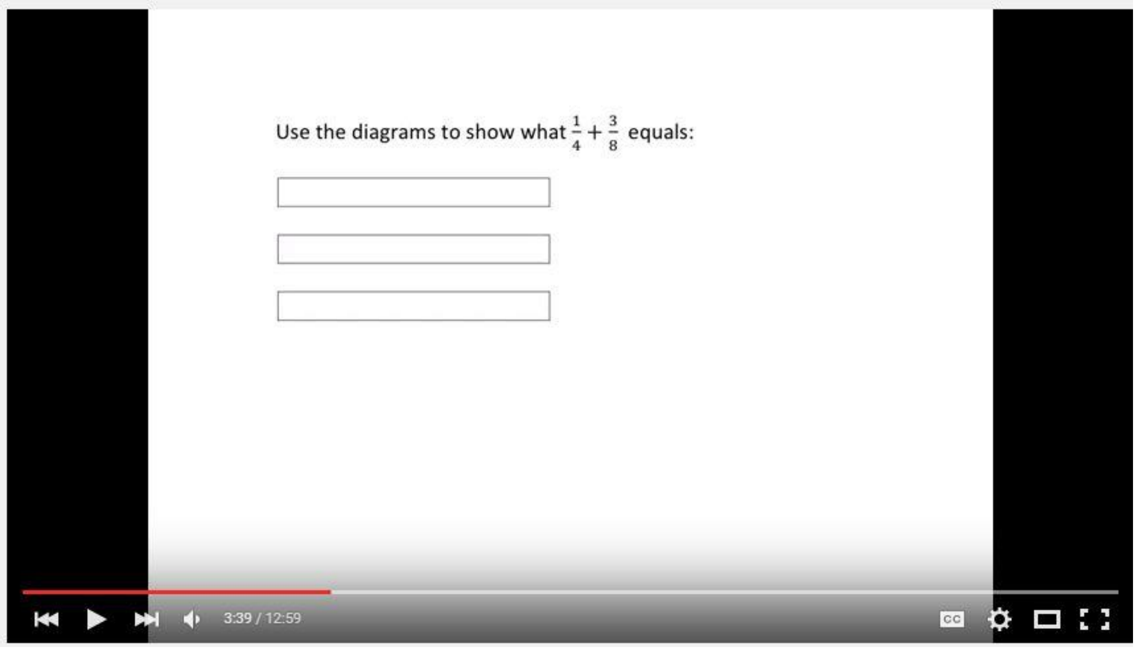


Figure 50: Fractions Lesson 7 video (English)

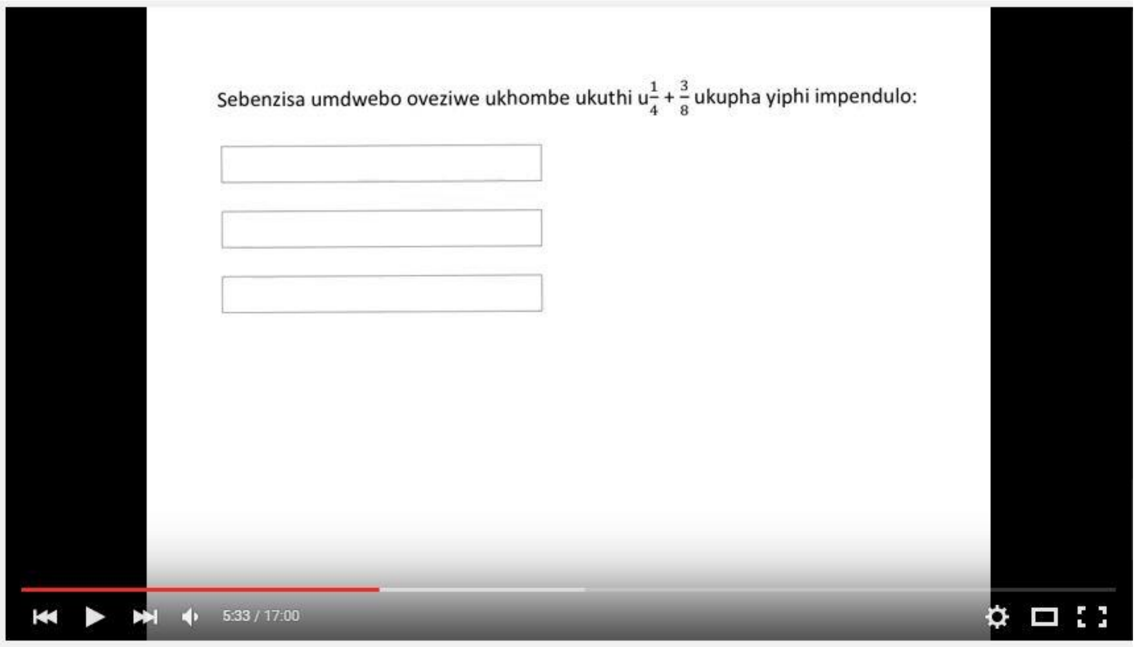


Figure 51: Fractions Lesson 7 video (English-isiZulu bilingual)

Fractions Lesson 7 was completed by 15 learners in the control group and 16 learners in the experimental group. The following is an example of the type of questions learners were expected to answer in the pre- and post-quizzes. Again, learners were encouraged to make use of the Geogebra plugin to visually represent the problem and to assist them in calculating their answers.

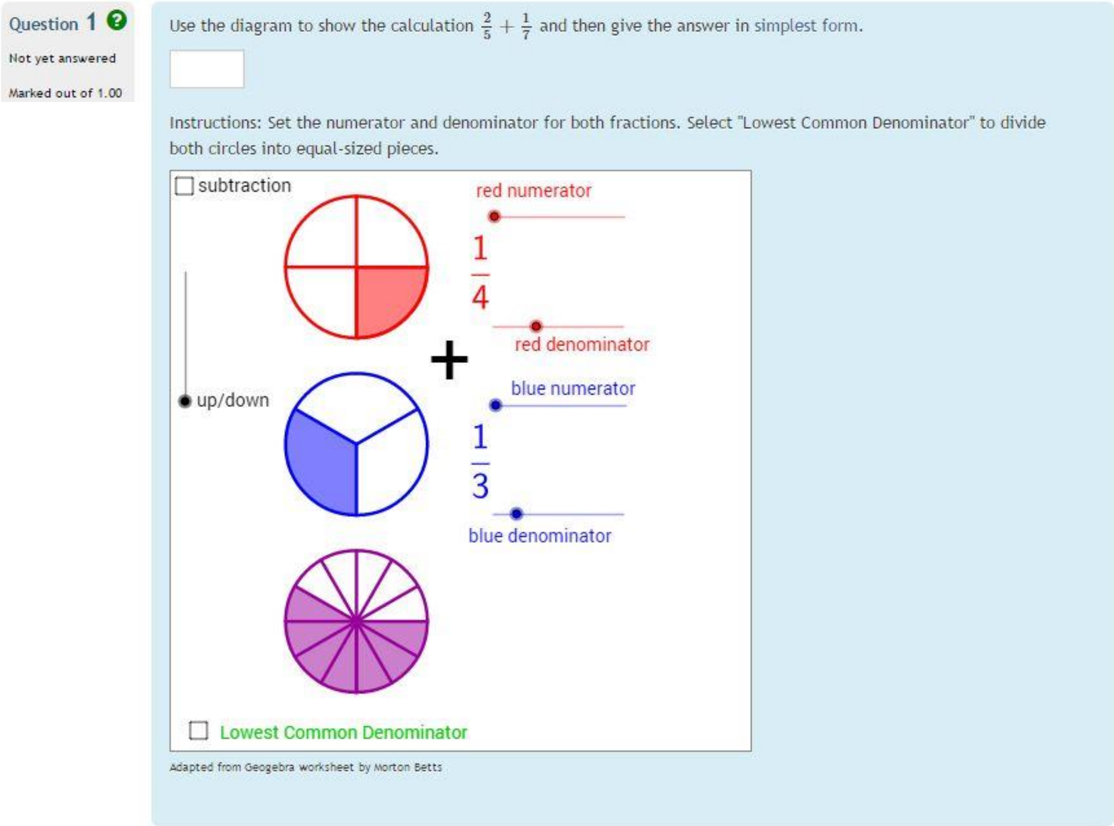


Figure 52: Fractions 7 questions

The control group scored an average of 23.81% for the pre-quiz and 35.24% for the post-quiz, showing an improvement of 11.43 percentage points. The SD of this group's improvement is 27.78. The experimental group scored an average of 14.29% for the pre-quiz and 31.1% for the post-quiz, showing an improvement of 16.82 percentage points. The SD of this group's improvement is 28.09. These improvements are illustrated in the graph below:

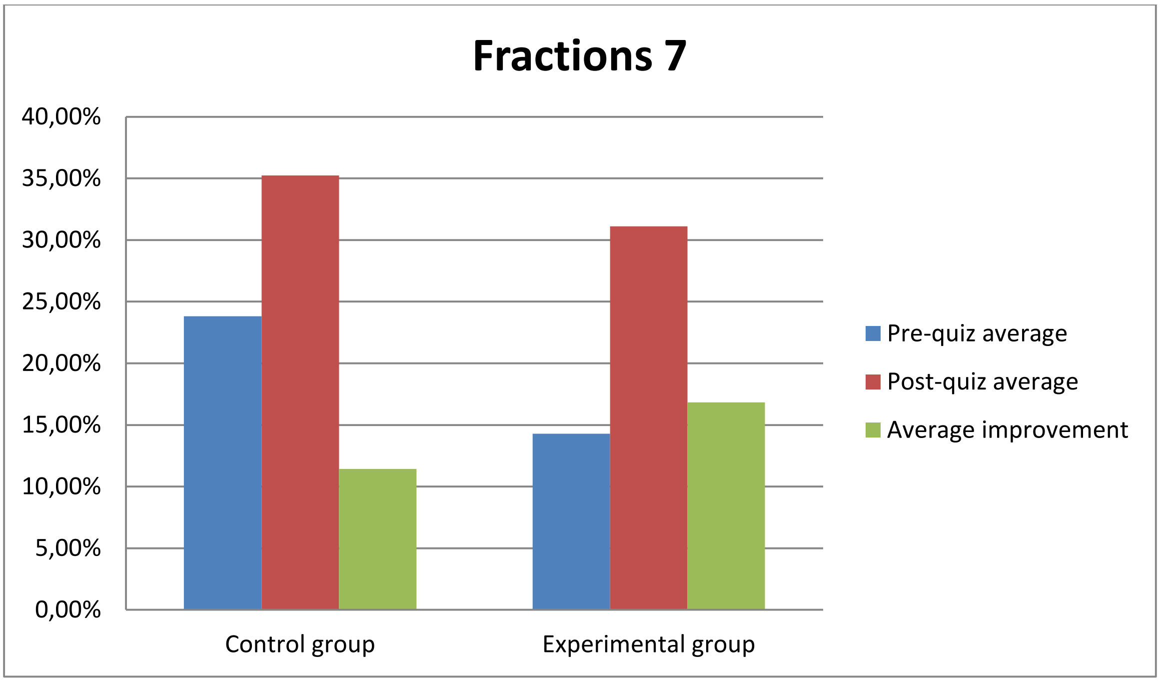


Figure 53: Fractions 7 improvement

The pooled SD is 27.94, and the effect size is 0.19. Rounding the effect size off to 0.2, this means that 58% of the control group would have shown less improvement than the middlemost-scoring learner in the experimental group. It is interesting to note that the control group had higher scores for the pre-quiz and post-quiz. This will be discussed in greater detail in the data analysis chapter.

4.3.8 Fractions Lesson 8: Multiplying fractions

Fractions Lesson 8 (see figs. 54 and 55) began by contextualising multiplication of fractions in a story about sharing a cake. In the story it is explained that if one is given $\frac{2}{3}$ of a cake and then shares $\frac{1}{2}$ of that portion with one's brother, one is left with $\frac{2}{6}$, or $\frac{1}{3}$, of the cake. Here it was made clear that when multiplying fractions one can simply multiply the numerators and the denominators respectively. However, the video then explained that this can sometimes be very complicated, and so wherever possible one should divide the numerator and denominator by the same number so as to simplify the fractions before multiplying them. Extracts from the videos are illustrated below:

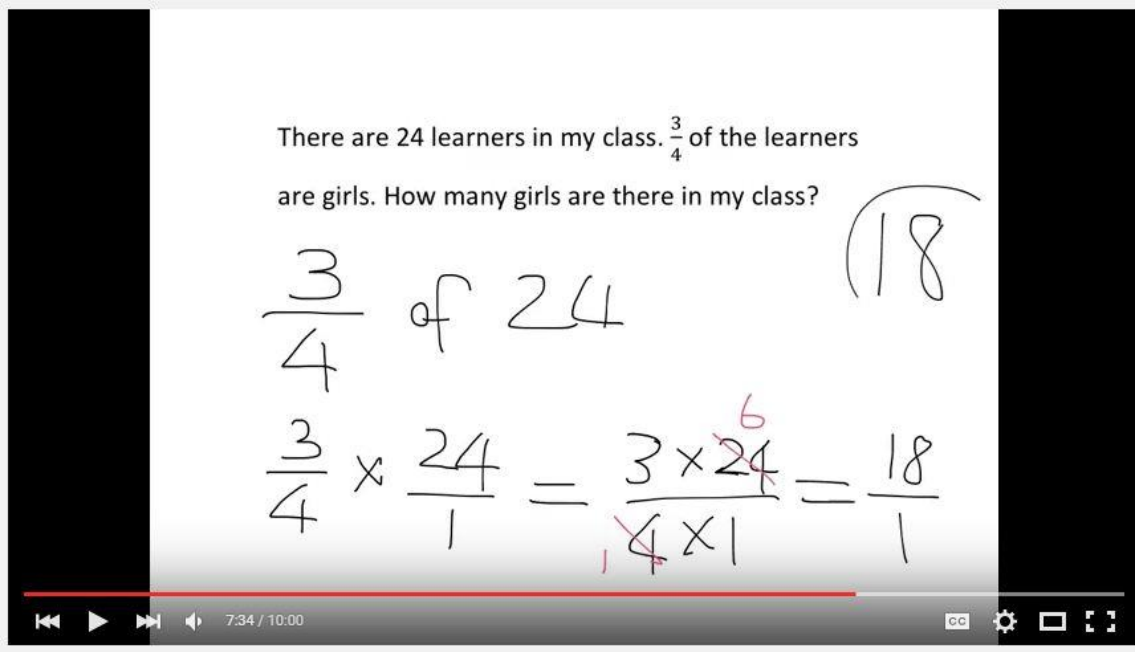


Figure 54: Fractions Lesson 8 video (English)

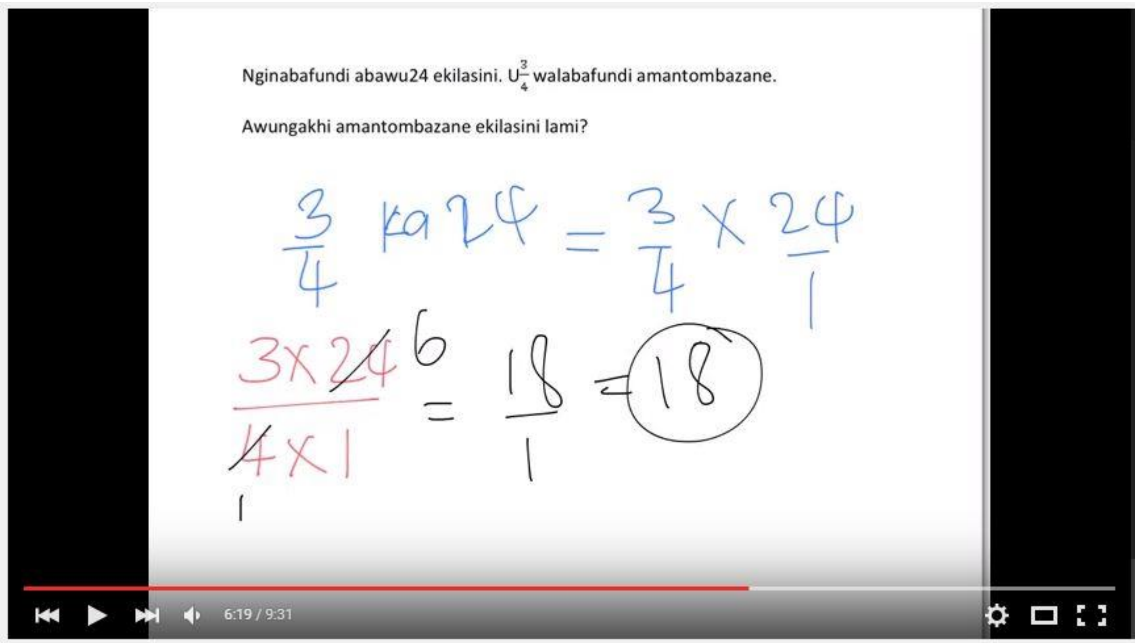


Figure 55: Fractions Lesson 8 (English-isiZulu bilingual)

Fractions Lesson 8 was completed by 15 learners in the control group and 10 learners in the experimental group. The following is an example of the questions learners were expected to answer for the pre- and post-quiz:

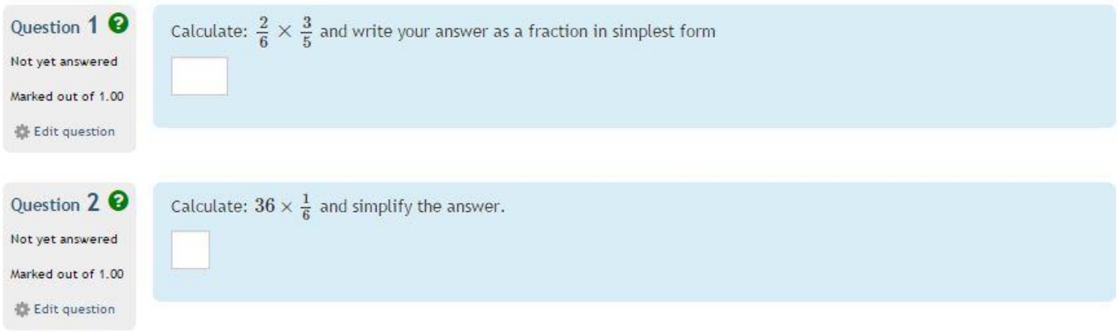


Figure 56: Fractions Lesson 8 questions

The control group scored an average of 26.67% for the pre-quiz and 49.33% for the post-quiz, showing an improvement of 22.67 percentage points. The SD of this group's improvement is 23.51. The experimental group scored an average of 22% for the pre-quiz and 48% for the post-quiz, showing an improvement of 26 percentage points. The SD of this group's improvement is 24.98. These improvements are illustrated in the following graph:

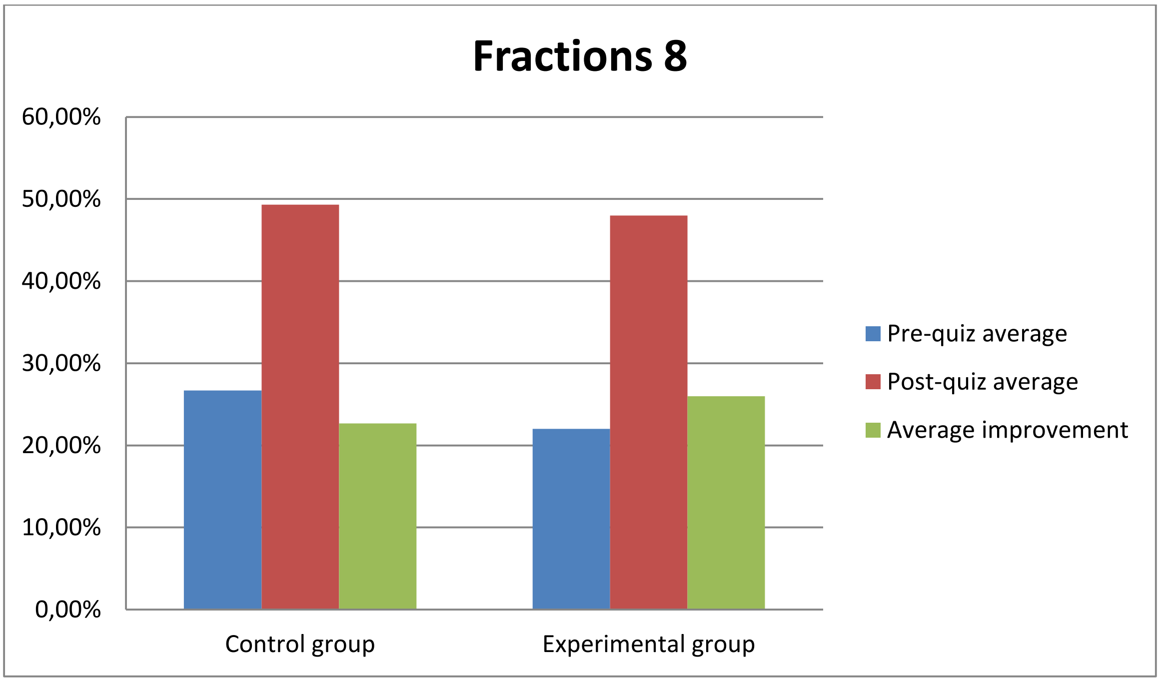


Figure 57: Fractions Lesson 8 improvement

The pooled SD is 24.09, and the effect size is 0.14. Rounding the effect size off to 0.1, this means that 54% of the control group would have shown less improvement than the middlemost-scoring learner in the experimental group.

4.4 Glossary usage

The hyperlinked online bilingual glossary was made available to all learners participating in the experimental English-isiZulu bilingual course. The glossary consisted of nine mathematics terms extracted from the course, each of which was accompanied by a short English definition and a short isiZulu definition. Of the 18 learners who signed up for the experimental English-isiZulu bilingual course, 15 learners used the glossary. The learners were expected to click on a hyperlinked term in the online mathematics course when they did not understand it, and the definition would then appear in a pop-up box. The Moodle programme recorded each click made by each learner on a hyperlinked term. The number of times each individual learner clicked on glossary terms is illustrated in fig. 58 below. The number of times each of the nine glossary items were clicked on is illustrated in fig. 59 below. Learners wrote a short quiz where they were asked to write definitions in any language of their choice for each of the glossary terms, and these quizzes were marked and used to assess whether learners had understood and retained the definitions of the glossary terms. The results of this quiz are then graphically represented in fig. 60.

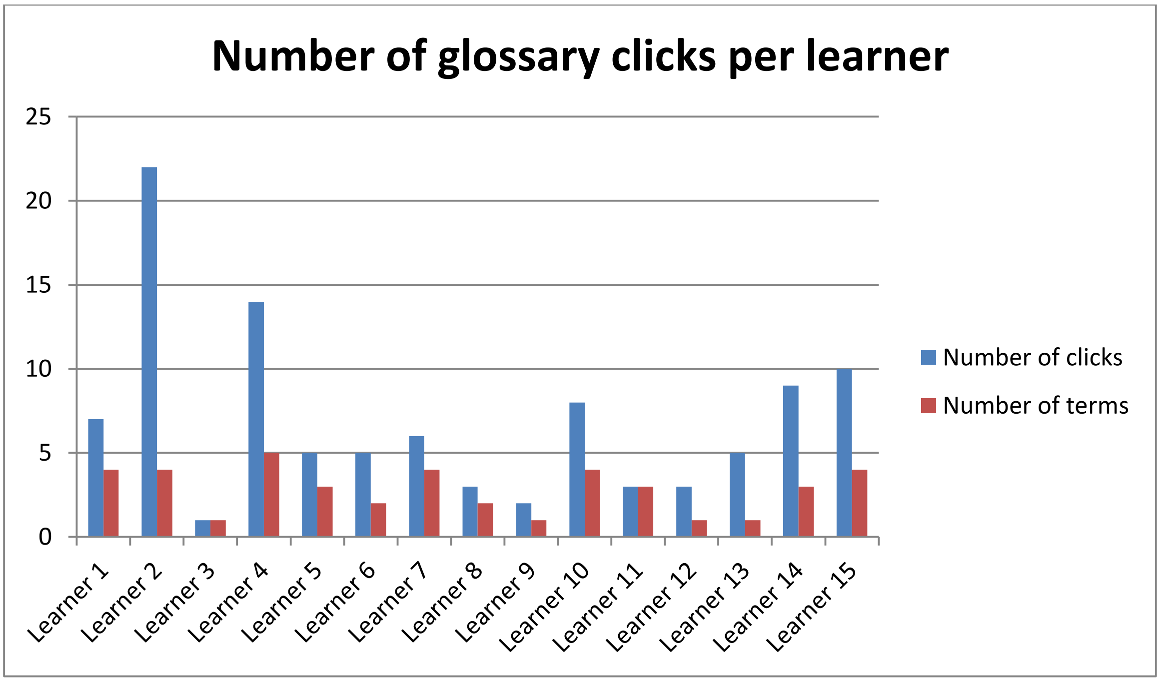


Figure 58: Number of glossary clicks per learner

The above diagram shows how many times each learner clicked on the glossary, as well as 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.

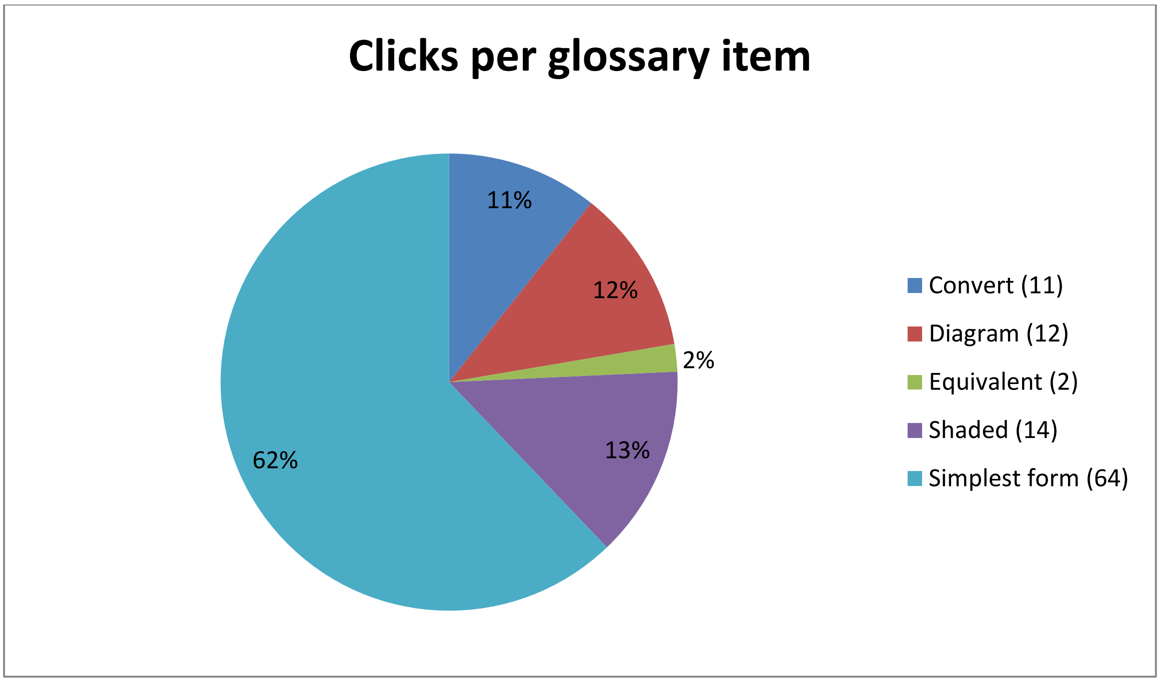


Figure 59: Number of glossary clicks per term

The above diagram 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.

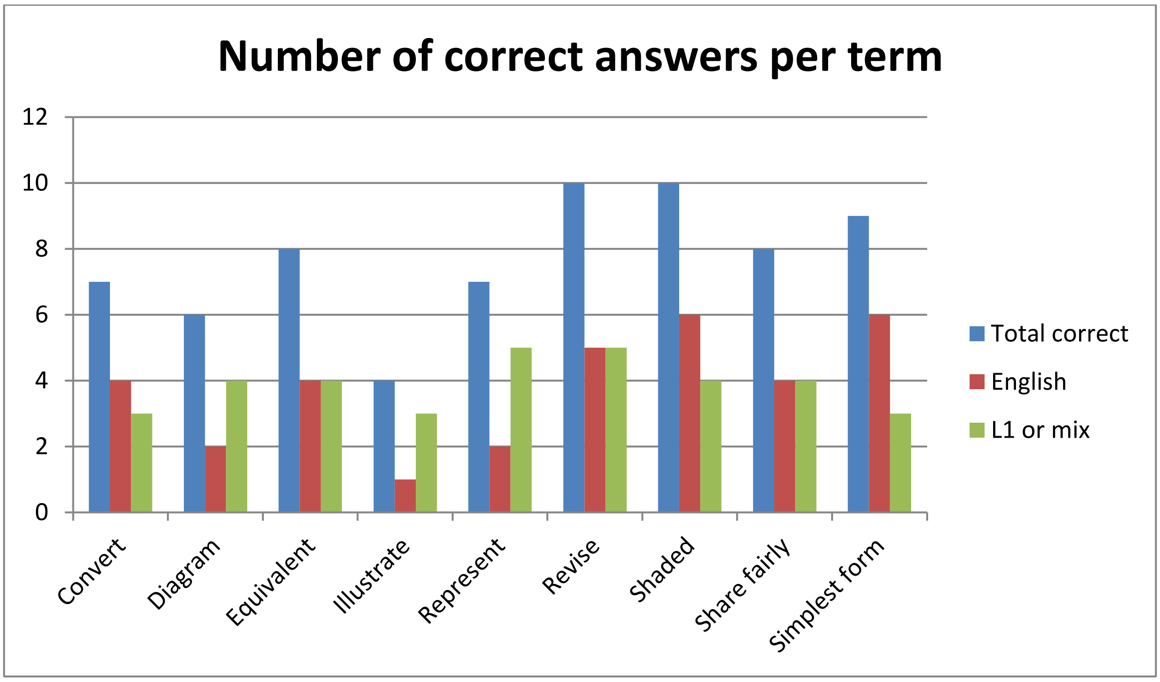


Figure 60: Number of correct answers per term

Fig. 60 illustrates the results of the glossary quiz the learners completed after the completion of the experimental course. 14 learners participated in this quiz. Only the results of the learners who participated in the experimental course are represented above in order to assess their understanding and retention of the terms learnt through the glossary. It is noteworthy that *illustrate*, a term that was not clicked on by the learners at all, was the lowest-scoring term. It is also interesting to note that several learners chose to answer in their L1 or a mix of languages, and furthermore that in doing so they often successfully explained the terms.

4.5 Feedback during the course

Throughout the course the facilitators and I made note of any feedback that was given spontaneously by the learners. This included feedback given by learners during their mathematics sessions, and any other time they were at the OLICO Youth centre, for example before or after a mathematics session or during a literacy session. The following is the feedback that was received.

In the early stages of implementation learners commented on certain technicalities of the videos, specifically that some of the writing in the first video was too small for them to read, and also that "*Thabiso wa re rasetsa!*" [Thabiso[8] makes a noise at us!], indicating that some of the learners were unhappy with the volume levels in the videos. It was also noted by the mathematics coordinator and the project co-founder that the English-isiZulu bilingual videos were longer than the English-medium videos. The quality assessor noted ambiguities occurring in isiZulu in Fractions Lesson 1:

> In terms of the language (Zulu), there needs to be caution of ambiguity that can confuse the learners, for example when explaining how to divide 6 parts to 6 children equally – what is written in the first box is '*Iziqephu umfundi azitholayo, uma sehlulwa izikhathi eziyisithupha*'. The word '*izikhathi*' here means 'times'. It would be best to stick to the word '*iziqephu*' (parts), also there is need to reference the 'whole' in this statement/explanation which means this statement could be rephrased as '*Iziqephu umfundi azitholayo uma ifizzer ephelele* (whole fizzer) *ihlulwa iziqephu eziyisithupha*'.
> (Appendix E)

In Fractions Lesson 2 both the mathematics coordinator and the quality assessor noted that the lines being drawn to denote fractions did not create equal parts, thus misrepresenting one of the core tenets of fractions.

[8] The bilingual resource creator

Following this feedback the following adjustments were made: writing was made larger in subsequent videos; the facilitators showed the learners how to adjust the volume of the videos if they found them too loud; the bilingual resource creator made the videos shorter (as will be discussed shortly); the bilingual resource creator took care to represent fractions as equal parts in his diagrams, and the use of *iziqephu* was used rather than *izikhathi*. In order to make the videos shorter the bilingual resource creator and I discussed why the videos were longer, and he explained that he would often explain a concept in multiple ways in case the learners had not understood the way he initially explained it. Furthermore, using isiZulu to paraphrase what has been said in English may in itself lengthen the speech, particularly as the compound terms common in academic English may not exist in the same form in isiZulu. We then discussed how the mathematics coordinator creates her videos by providing one explanation, and that learners should ask the facilitators for alternate explanations should they require them. The bilingual resource creator and I then decided that he would follow suit and provide only one explanation of a concept in the way he deemed to be most easily understandable. This reduced the time of the experimental videos.

Two weeks into the term I held an informal unstructured interview in which I broadly asked the learners what the best thing about this term was, be it at OLICO, at school or at home. The first response given was, “The best thing about this term is that the videos are in isiZulu! It makes it much more easy.” Throughout the course we received feedback from several learners. One of the learners commented that the experimental videos were difficult, but upon enquiry he was unable to give feedback as to why. His inability to explain why he found the videos difficult could be due to insufficient CALP (as has been observed with many learners who are unable to articulate cognitively demanding thought), lack of metacognition resulting in an inability to recognise what one does not understand, or self-consciousness resulting in him not wanting to expand on what he had said. 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”. They also noted that the bilingual resource creator spoke loudly and clearly in the videos, making it easier for them to hear what was being said. Another learner commented that she liked the videos because they were easy, and another commented that the videos were easy because she was now able to understand the words she hadn’t understood before.

4.6 Parent discussion group

A discussion group was held with the learners' parents at the first parents' meeting of the year, on 7 February 2015. This discussion group was held with the intention of identifying parents' attitudes towards English, their home languages, and the roles of these languages in the academic space. As parents' support was vital for this project to take place this discussion was very important in assessing whether the project would be viable. This discussion furthermore intended to ascertain how these parents' attitudes related to the literature, particularly with regard to the general observation that South African parents are wary of incorporating African languages as LoLT. In order to encourage open dialogue this discussion was hosted in a manner in which all answers were welcomed.

All parents were invited to attend the parents' meeting, although not all parents were able to do so. Roughly 60% of parents attended the meeting. Many parents were unable to attend because they work on Saturdays, or due to family commitments. It was compulsory for the learners to attend the meeting, and as such they were also included in this discussion.

The following are the questions I had prepared for the discussion:

1. What do we mean by literacy?
2. Why is literacy important?
3. What are our views on different languages?
    a. Do we think it is important to learn English? Why?
    b. Do we think it is important to learn in English? Why?
    c. Do we think it is important to learn African languages? Why?
    d. Do we think it is important, or useful, to learn in African languages? Why?
    e. Do we think it could be useful to learn through both languages? How, and why?

I led the discussion group by informing the parents that I would be doing a literacy programme with their children that year, that I would be doing my Masters research on elements of this programme, and requested their input to inform this. The discussion began with the question "What do we mean by literacy?" The learners were quickest to respond, and stated that literacy means 'English'. When asked why literacy is important, a learner stated "It teaches about other languages", and a parent spoke about how literacy enables us to communicate. I asked whether the group thought it was important to learn English, to which the response was a resounding “Yes” from the parents, who then explained that it is important to learn English because it is a medium of instruction, and because it allows us to communicate everywhere. This lead to the question of whether the group thought it is important to learn in English, to which parents responded “Yes” because school subjects are taught in English and school textbooks are in English. I then asked the group whether they thought it was important to learn African languages. Again, there was an agreement of “Yes” from the parents, as they stated that their language “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 showed their agreement with this suggestion. I had initially intended to ask whether the group thought it could be useful to learn through L1 and English, but following this parent’s suggestion I no longer needed to ask this question. 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, and that we would keep in touch with further details closer to the time.

4.7 Pre-course surveys

The pre-course surveys were completed by 34[9] OLICO Youth Grade 7s before they began the experimental course. The aim of this survey was to find how learners had been experiencing the OLICO Youth course, particularly the videos, and to gain insight into their attitudes towards different LoLTs. The surveys were conducted in English due to the linguistic limitations of the researcher. Each learner completed the following survey:

Name: ______________________ olico Grade: _______

Questions about OLICO videos

How easy are the videos?

- ☐ 1. Very difficult, I don't understand them
- ☐ 2. Difficult, I often don't understand them
- ☐ 3. Ok, but sometimes I don't understand
- ☐ 4. Easy, I understand most of them
- ☐ 5. Very easy, I understand everything

How easy is the maths you do at OLICO?

- ☐ 1. Very difficult, I don't understand them
- ☐ 2. Difficult, I often don't understand them
- ☐ 3. Ok, but sometimes I don't understand
- ☐ 4. Easy, I understand most of them
- ☐ 5. Very easy, I understand everything

Would you prefer to watch the videos in your home language?

Yes No

Why or why not?

____

____

____

Do you have any comments about the videos?

____

____

____

Figure 61: Pre-course survey

[9] The written responses of one learner have been omitted as she is functionally illiterate: her written work consists of words she sees written in her immediate environment, which she then replicates in an incomprehensible order.

The following are the results from these surveys:

1. How easy are the videos?

The following diagram shows learners' perceptions of the level of difficulty of the videos. Most learners perceive the videos to be easy. It is interesting and positive that no learners find the videos very difficult or difficult.

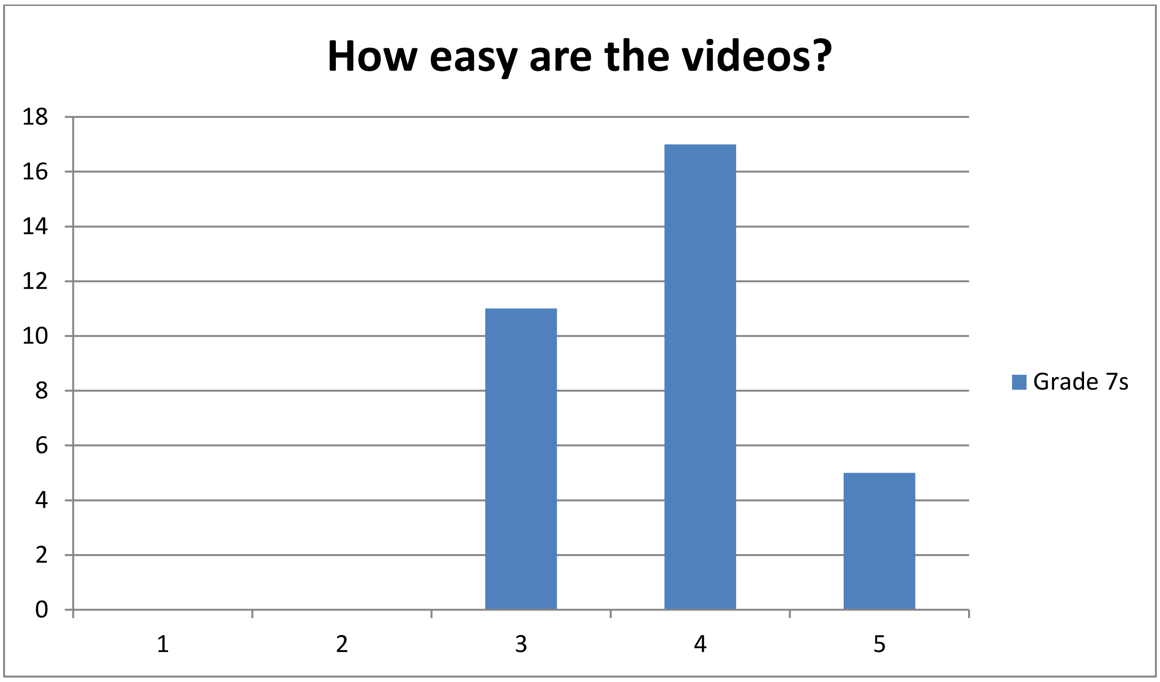


Figure 62: How easy are the videos?

2. How easy is the Maths you do at OLICO?

The following diagram shows learners' perceptions of the level of difficulty of the mathematics they do at OLICO Youth. Again, most learners perceive the mathematics to be easy. While there are no learners who find the mathematics very difficult, there are two learners find the mathematics difficult.

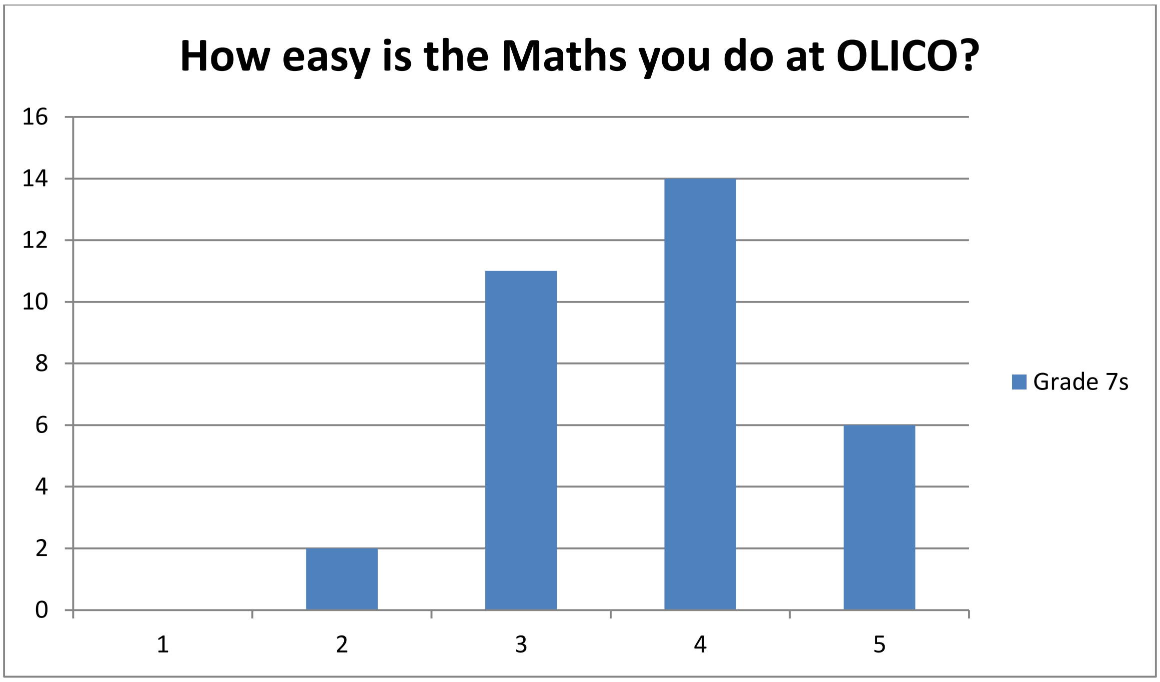


Figure 63: How easy is the Maths you do at OLICO?

3. Would you prefer to watch the videos in your home language?

As illustrated in the figure below, the majority of learners would not choose to watch the videos in their home language.

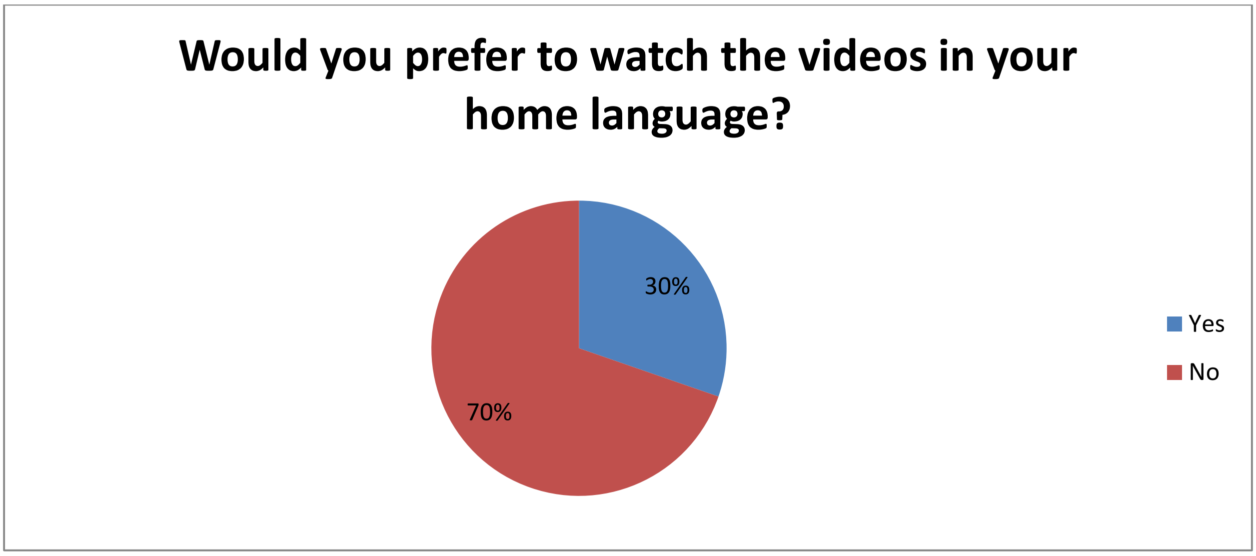


Figure 64: Would you prefer to watch the videos in your home language?

4. Why or why not?

Learners gave various reasons for their answers. In examining these answers certain trends became apparent. These trends are represented in tables 3 and 4 below, after which selected reasons from the learners are given.

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

Table 3: Reasons for *No*

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

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

Table 4: Reasons for *Yes*

Some of the reasons given for this include:

- Because I will be able to know the steps they show which mean 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. Do you have any comments about the videos?

Learners were given the opportunity to add any comments they might have. Some learners opted to make no comment. Trends were once again identified in the comments that were made. The following is a breakdown of the comments given by learners:

Comments from learners					
Videos help us understand Maths	Do not understand the videos	Like the videos (no reason given)	The videos are too long	Videos are easier than exercises	Add another language
64%	11%	11%	8%	3%	3%

Table 5: Comments from learners

Some of the reasons given for this include:

- I think the videos help a lot, because they show how to do all the work you are on at that time
- The videos are too long and I don't understand most of them
- The videos are very cool
- They are really helping, but I don't understand why they don't change the numbers if you get a big number they'll give you a video of a small number

- Yes! We have to add other language

4.8 Discussion groups

Small discussion groups were held immediately after the completion of the individual questionnaires. They were facilitated by 16 Winter School volunteers, with eight groups of four to five learners and two volunteers per group, again with 34 learners in total. The learners discussed the surveys they had just completed, allowing them to expand on their views, discuss and possibly challenge each other's views, and also to grant another avenue of expression to learners who do not express themselves easily through writing. Wherever possible, learners were encouraged to discuss the questions in whichever language they chose, although this was naturally influenced or limited by the volunteers' different language proficiencies.

Below follow the questions asked in the discussion groups. Trends were identified in the learners' answers and are represented below, accompanied by examples of these trends selected from the learners' answers.

1. How easy are the videos?

This question dealt primarily with learners' understanding of the mathematics they learnt through the videos. While language naturally would factor into this, it was not brought to the fore in this question as this question aimed to get general feedback from the learners about their experiences of the videos. The learners' answers are summarised in table 6 below:

How easy are the videos?								
Too easy/very easy	Easy	Helpful	Ok/easy and difficult	Not easy	Difficulties	Criticisms	Description	Language
7%	22%	15%	26%	11%	7%	4%	4%	4%

Table 6: How easy are the videos?

One group that said the videos were too easy argued that, "Videos are sometimes too easy and not helpful when answering questions" implying that they thought the content covered in the videos was easier than the content covered in the quizzes, and as such they were not adequately prepared for the quizzes by watching the videos. A group that said the videos were easy supported this by saying that the videos "show you how to do a sum before you do it," and another group said the videos were "easy, because of the step by step instructions." One group said that the videos were helpful "and they help my understanding." Seven learners spoke about their mixed experiences of the videos, saying that they were "sometimes simple, at times difficult" and that they were "easy, but some steps are hard to understand."

Other learners found the videos difficult, saying “they’re not easy at all”, while others acknowledged their struggle and success in understanding the videos: “the videos are not really easy, but they’re very helpful.” Two groups drew attention to specific videos they had found difficult, and one criticised the length of the videos. One group did not answer the question but instead explained what the videos do, stating that “they show how to calculate methods,” and one group stated that “we prefer the videos in both English and home language.”

2. How easy is the Maths you do at OLICO?

Learners’ answers to this question are summarised as follows:

How easy is the Maths you do at OLICO?				
Easy	Ok/mixed	Difficult	Specifics	Description
23%	23%	23%	23%	8%

Table 7: How easy is the Maths you do at OLICO?

The groups that felt the mathematics is easy attributed this to the fact that some of the work they do at OLICO Youth had already been covered at school, and “because they show us the steps of where to start and end.” Other learners shared a mixed reaction, with some learners citing specifics of which courses they found easy and which they found difficult, and others citing the different levels of difficulty within the lessons: “At the beginning it’s easy but from about the third question it’s very difficult and I cannot understand”. Those who found the mathematics difficult noted that the concepts they learn at OLICO Youth are different to what they have already learnt at school, making it more difficult to grasp, with others quite simply saying “most are difficult, and I struggle often.” It is interesting that in these discussions there is an equal split between comments citing the mathematics as being easy, mixed level of difficulty, and difficult.

3. Would you prefer to watch the videos in your home language?

As evidenced in table 8 below, the majority of learners would prefer to watch the videos in English.

Would you prefer to watch the videos in your home language?	
Yes	No
38%	62%

Table 8: Would you prefer to watch the videos in your home language?

Trends in their reasons were once again identified in the comments that were made. The following tables show a breakdown of the comments given by learners:

The videos should be in our L1		
We understand better	We should mix languages	No reason given
38%	38%	24%

Table 9: The videos should be in our L1s

The videos should be in English			
Our community is multilingual	We understand English better than our L1s	English is LoLT	No reason given
8%	76%	8%	8%

Table 10: The videos should be in English

In considering the emerging trends in learners' answers it is clear that the majority of learners would prefer to watch the videos in English because, as one learner said, "I'm not used to terminology in my home language." Interestingly, the learners who would rather watch the videos in their L1 made this decision because they understand their L1 better than English.

4.9 Post-video interviews

A sample of learners was selected for interviews at the end of the course. Learners could self-select for the interviews, and I interviewed eight learners out of the 40 learners. These learners had shown different performance levels on the course, consisting of four learners from the English-medium control group and four learners from the bilingual experimental group. In these interviews I asked them questions about their perceptions of the course, their emotional and motivational responses, as well as tested their understanding of the content in the videos (see Appendices E and F for questions and transcriptions respectively). The latter was tested by giving learners a mathematics problem relating to a concept they would have learnt in the video they most recently watched. I then asked them to solve the problem and explain it to me as though I was their peer who didn't understand. I specifically conducted these interviews myself (as opposed to asking a multilingual colleague) as the learners then needed to explain in English, and the purpose of the videos was to help the learners build understanding and proficiency in English within the topic.

In these interviews the learners informed me that they had covered almost all of the topics covered in the OLICO Youth Fractions course at school, except for word problems and multiplication of fractions. Where the method in the OLICO Youth video differed from the method taught at school, most of the learners followed the methods they had learnt at school.

When I asked one learner if she could also show me how to do the problem using the method she had learnt in the video, she replied, "I don't know, I was doing the method like this." This illustrates the dichotomy of the mathematical elements in this research being divided by conceptual understanding and procedural fluency, as mentioned in the analytical framework.

When I first asked one of the learners to explain to me how she had solved the mathematics problem as though I did not understand it she was taken aback. "Ha! Why?" she asked me, and clearly explaining a concept to someone who already understood it was a foreign task for her.

In explaining to me how they answered the mathematics problems all of the learners simply showed me what they had done. Learners showed me their calculations, but did not explain why they were doing them. The following extract taken from after the learner's successful completion of a mathematics problem illustrates learners' degree of procedural fluency but relative lack of conceptual understanding:

> NvW: Yoh, you've learnt so much hey. So what does this 40 mean, compared to that?
>
> L: Um.
>
> NvW: What is this question asking you?
>
> L: They say change, eish, I don't know it now.
>
> NvW: Ok, but you know how to do it which is great.
>
> L: Yes.
>
> (Learner 1, Appendix F)

The reward for procedural fluency over conceptual understanding that is so prevalent in schools even echoes in my affirmation that her knowing how to do it is great. When considering all of the interviews it is clear that the bilingual experiment with the videos alone is not sufficient to improve learners' conceptual understanding of mathematical concepts.

4.10 Post-video Surveys

Learners completed short questionnaires early in the fourth term once they had completed Decimals, the course which followed Fractions which was available in English only. The purpose of these surveys was to see what learners' perceptions of learning through their L1 were after having gone back to learning in English only. The following are the results from the surveys.

1. How easy or difficult was the Decimals course?

The following Likert-type options were provided for this question: *Very easy, easy, ok, difficult, very difficult.* Figs. 65 and 66 illustrate the learners' answers:

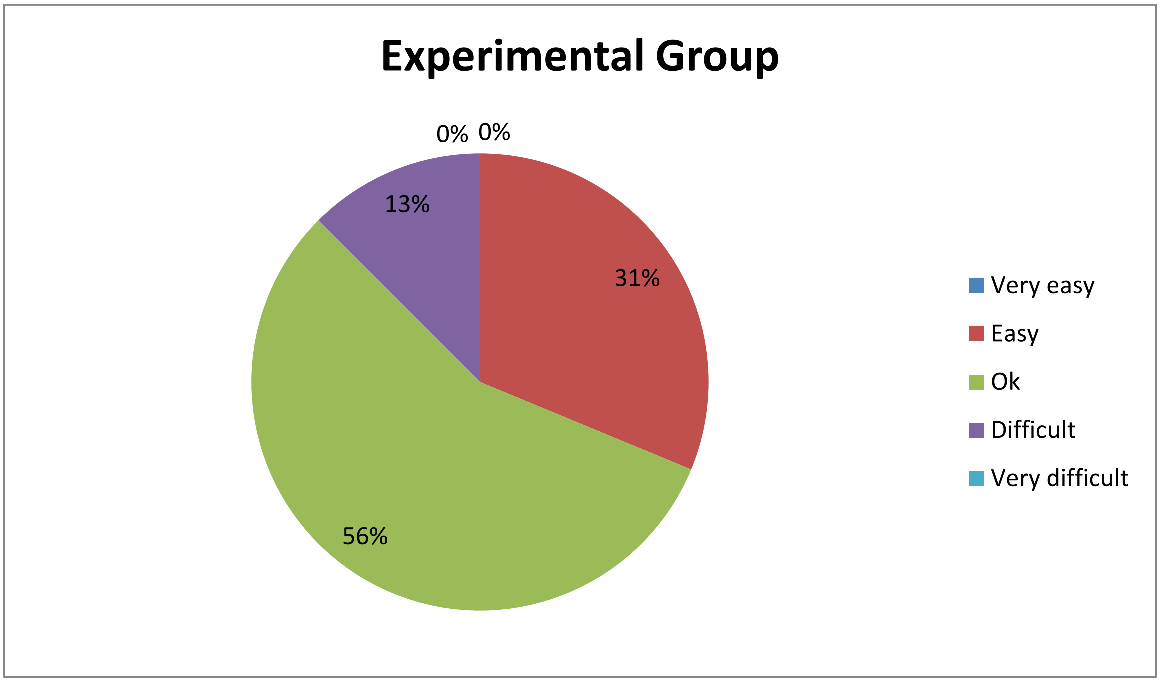


Figure 65: How easy was the Decimals course? (Experimental group)

In the above diagram it is clear that most learners in the experimental group found the Decimals course *ok*, with no learners rating it in the extremes of *very easy* or *very difficult*.

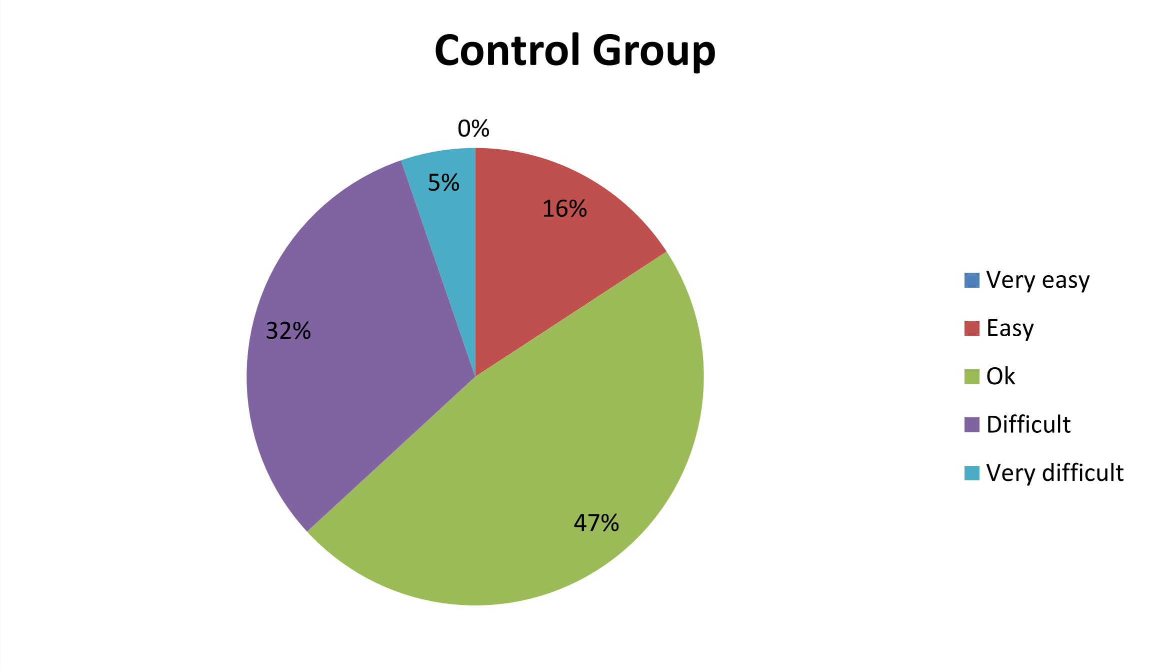


Figure 66: How easy was the Decimals course? (Control group)

When considering the control group it appears they found the Decimals course to be more difficult than the experimental group did, with more learners saying it was *difficult*, fewer saying it was *easy*, and 5% also saying it was *very difficult*.

2. Why?

Learners were asked to give reasons for their answers listed above. This question was intentionally ambiguous, as it aimed to discover whether learners identified the LoLT of the videos as an influential factor in their learning experiences without being prompted to speak about it. The following are the reasons given by the learners in the respective groups as to why they found the Decimals course to be the level of difficulty they stated:

Easy: The learners in the experimental group found the Decimals course easy because they watched the videos, understood the course and had also done decimals at school. The learners in the control group also found the Decimals course easy because they had done it at school previously.

Ok: The learners in the experimental group found it ok because they struggled with the basic operations of some numbers, and learners in both the experimental and control groups found some elements easy and other elements difficult.

Difficult: The learners in the experimental group found it difficult because they simply did not understand decimals.

Very difficult: The learner in the control group found it very difficult because they found a lot of questions very difficult to understand.

3. How easy or difficult was the Fractions course?

The following Likert-type options were provided for this question: *Very easy, easy, ok, difficult, very difficult.* Figs 67 and 68 illustrate the learners' answers:

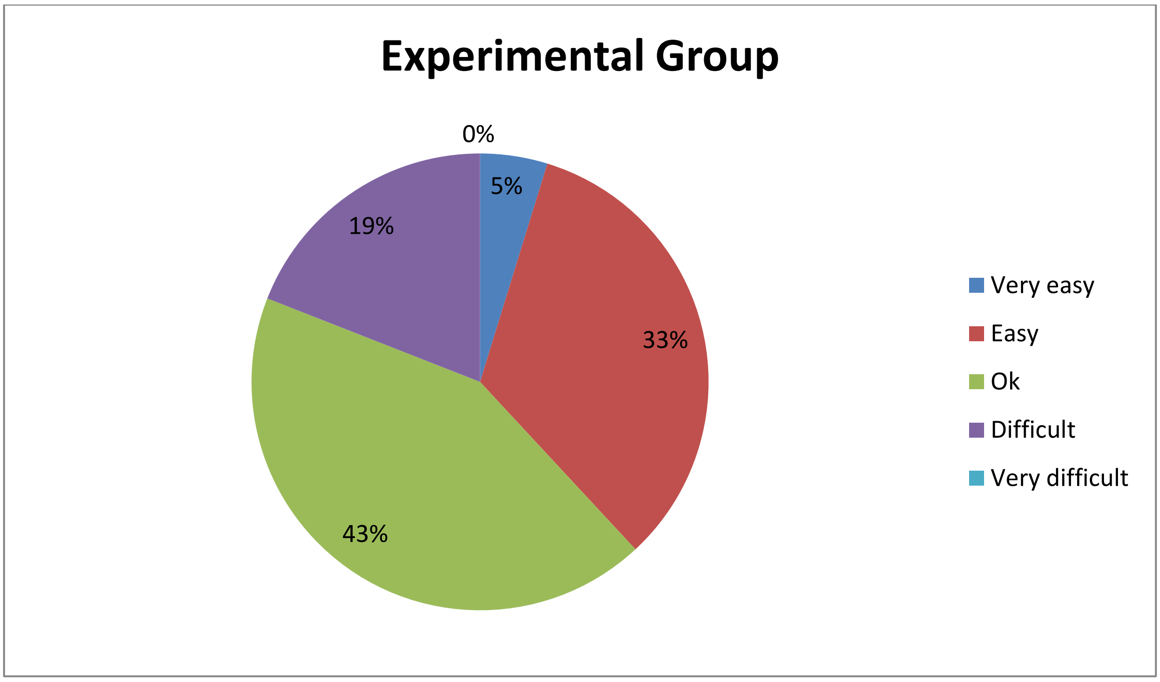


Figure 67: How easy was the Fractions course? (Experimental group)

If we are to compare the above diagram to that of the experimental group's perception of the Decimals course we can see that this group found the Fractions course easier, as the percentage of learners who found it *easy* has increased, and there are also learners who found it *very easy*.

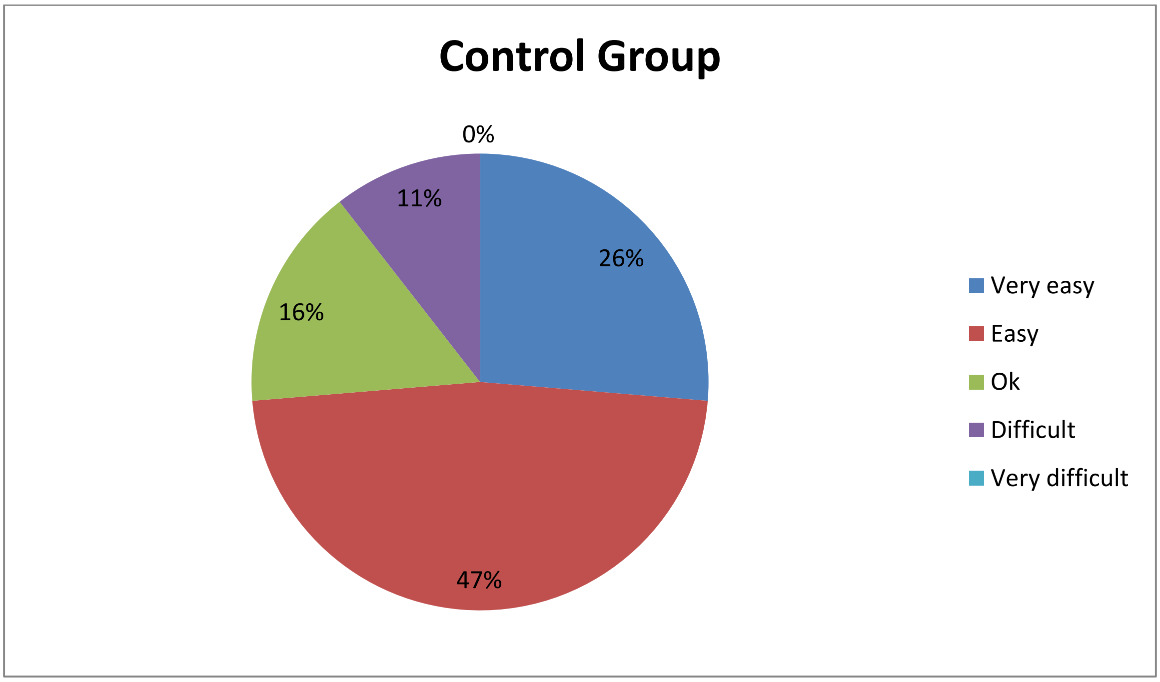


Figure 68: How easy was the Fractions course? (Control group)

If we compare the control group's experience of Fractions we can see that they found it easier than the Fractions course, and also that the control group found Fractions easier than the experimental group did.

4. Why?

The following are the reasons given by the learners in the respective groups as to why they found the Fractions course to be the level of difficulty they stated:

Very easy and *easy:* The learners in both groups had previously learnt fractions at school.

Ok: The learners in the experimental group found it ok because they struggled with the basic operations of some numbers, and learners in both the experimental and control groups found some elements easy and other elements difficult.

Difficult: The learners in the experimental group found it difficult because they did not understand some of the questions, and the learners in the control group did not understand some of the videos.

Very difficult: The learner in the control group found it very difficult because they found a lot of questions very difficult to understand.

5. What is a decimal? You can use sentences, pictures, numbers, or anything you want to explain it.

In order to assess learners' conceptual understanding, they were asked to explain what a decimal and a fraction is. Almost all of the learners just wrote examples of decimals and fractions, and some of them made reference to technicalities of the numbers, for example a fraction has a numerator and a denominator and a decimal has a comma. None of the learners were able or attempted to explain the concept of a decimal or a fraction.

4.11 Post-video discussion

A short discussion was held with 34 learners following the completion of their surveys, which were hosted in two groups. During this discussion they were asked whether they would choose to do the OLICO courses in English or in a mixture of English and their L1 in the future. Learners were then encouraged to give reasons for their answers.

The first group was adamant that English is the most important language and for that reason they should be learning in English, also arguing that English is easier to understand. The second group entertained more debate around this topic, with roughly half the group arguing in favour of English, also citing the importance of English and the other half arguing in favour of a mixture of both languages, stating that they could understand better in their L1.

In both groups learners also enthusiastically suggested creating videos in a variety of languages, notably Sepedi, Setswana, isiZulu, isiXhosa, Sesotho, chiShona, Xitsonga and, interestingly, Afrikaans (which was the only language other than English that was suggested not because it is used by learners, but because it is a language the learners wish to learn).

4.12 Conclusion

This chapter has presented the various data that was collected in this research project. The data was collected in order to inform the following research questions: how learners L1s can be viably incorporated in learning; how the use of translanguaging in the online OLICO Youth mathematics course promoted learners' conceptual development; and how the use of translanguaging in the online OLICO Youth mathematics course affected learners' attitudes to learning.

A discussion group was held with parents at the beginning of the year, where it was suggested by one of the parents that both English and the learners' L1s should be used in the classroom to facilitate optimal content understanding and English acquisition. In the pre-course surveys and discussion groups it was found that the majority of learners would prefer to learn in English than in their L1s, reporting that they understood English better than they understood their L1s. In the post-video interviews it was found that learners often fell back on procedures they had learnt at school rather than understanding the concepts behind the procedures, irrespective of the language in which they had watched the videos.

In the post-video surveys and discussions many learners argued in favour of learning in English, citing the language's prestige, while other learners argued for the incorporation of both their L1s and the L1s of their peers to be incorporated into the OLICO Youth mathematics course.

In considering the learners' pre- to post-quiz improvement, it is evident that there is no clear quantitative trend between the improvement of the experimental group that completed the course in English supplemented by English-isiZulu bilingual videos and online and hardcopy English-isiZulu bilingual glossaries, and the control group that completed the course in English only. It is encouraging to note that all groups did show notable improvement after watching the videos. The possible reasons for noteworthy effect sizes in these results will be discussed in further detail in the upcoming data analysis chapter.

The glossary was well-used by the learners, with most learners clicking on one to five glossary terms. There were clear differences between the number of clicks on different terms, 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.

Feedback on the videos and glossary was received from the quality assessor, OLICO Youth facilitators, the mathematics coordinator, the project co-founder and the learners. The feedback was generally positive, and where shortfalls were identified the relevant changes were made.

The data that has been presented in this chapter will be discussed in greater detail in the following chapter.

Chapter 5: Data Analysis

5.1 Introduction

This research set out to: find out how learners' L1s can be viably incorporated in learning, specifically in the context of the supplementary mathematics programme already in existence at OLICO Youth in Diepsloot, Johannesburg; find out how the use of online translanguaging in the OLICO Youth mathematics course promoted learners' conceptual development, specifically their development of mathematical concepts; and find out how the use of online translanguaging in the OLICO Youth mathematics course affected learners' attitudes to learning, particularly in terms of learners' motivation and their perceived value of their L1s. In order to explore these objectives the following data was collected: parents' attitudes; learners' attitudes before, during and after the experiment; learners' mathematical conceptual knowledge before, during and after the experiment; and learners' mathematical language proficiencies after the experiment.

5.2 Findings

5.2.1 Introduction and overview

It was found that, quantitatively, the video-based translanguaging made little to no difference on learners' conceptual development of mathematical concepts, yet qualitatively it did influence and affirm learners' valuation of their L1s in the learning environment. This is attributed to the very short space of time over which the experiment was conducted, as reasoned by the mathematics coordinator and quality assessor. This is further attributed to the fact that this experiment went only as far as the first iteration, requiring it to be evaluated, improved, and implemented again. The minimal quantitative improvement does not, however, indicate a failure of this experiment. 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 enriched learners' motivation and sense of self-worth.

The experimental glossary improved learners' language proficiencies as they recalled many of the terms they had clicked on, and it improved their attitudes to using their L1 in the mathematical context as several learners chose to use their home language to explain the English terms. The use of translanguaging showed evidence of positively impacting learners' attitudes to learning, particularly with respect to learning through their L1. This was evidenced by learners' positive feedback and evident enthusiasm throughout the experiment, which 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.

While the creation and implementation of the experiment were informed by a broad spectrum of literature on the topic, it was also inextricably influenced by my own experiences as a researcher. My previous research experience was gained in the Joza township of Grahamstown, Eastern Cape, where isiXhosa is the L1 of almost all the learners and teachers and English is rarely used or heard outside of class time. This is in line with the point raised by Setati and Adler (2000: 255) that in rural schools the teacher is often the learners' only source of English exposure. This is also a very different context to that of Diepsloot, Johannesburg, where linguistic contact between people of varying L1s is the norm, resulting in multilingual children who, in this significantly more urban township, also hear and use more English, in line with the research of Soudien (in Probyn, 2009: 127). That is to say, I may have underestimated the difference which may be likened to that between foreign language learning and second language learning contexts (Setati et al., 2002: 130). As such the difficulties of developing CALP and learning in English experienced by the learners in this study is probably less significant than that experienced by learners in my previous research.

This research did, however, illustrate the positive impact of incorporating learners' L1 in learning particularly with regard to their sense of self and valuation of their L1. This speaks to both personal and political values. The linguistic and mathematical value added by the L1 may not have been apparent in the quantitative data, but the creation of spaces in which learners' L1 can be incorporated into their education is dependent on increased personal and political value held by the L1.

As suggested by Baker and Hornberger (2001: 38), it is indeed clear that the learners' multilingual development is impacted by the language attitudes of those around them and the prestige and prevalence of the languages in their contexts. This is seen in learners' constant referral to the need to learn through the medium of English because of its prestige and function, which is reflected by their parents' attitudes.

5.2.2 Pre-quiz to Post-quiz improvement in Fractions course

The difference in improvement between the experimental and control groups was inconsistent and inconclusive. The experimental group showed more improvement in Fractions 1, 4 and 7, the control group showed more improvement in Fractions 6, and no significant difference in improvement was seen in Fractions 2, 3, 5 and 8. Learners were only included in the analysis of a lesson if they achieved less than 80% for the pre-quiz. Furthermore, not all the learners completed all the lessons, as learners who struggled with the lessons did not complete lessons as fast as their peers and, if they did not attend catch-up sessions, they fell behind. This means that they could not complete all eight lessons within the given time period, indeed whether or not they reached the lesson at all, as the learners who completed each Fractions lesson differed slightly in each lesson. As the videos progress they become more context-reduced, meaning learners become increasingly dependent on the language being used as they are unable to draw meaning from the context (Baker and Hornberger, 2001: 43). It is therefore interesting that there is no obvious trend in pre-quiz to post-quiz improvement as the lessons progress.

In Fractions 1, it is noteworthy that learners in the experimental group showed more improvement than control group. This goes against the expectation that learning in an unfamiliar LoLT (in this case, the learners' L1) can be confusing for learners and throw them off track. While this is most likely due to learners gaining better understanding through their L1 as LoLT, this could possibly also be attributed to increased enthusiasm and attentiveness due to the newness and novelty of the experimental course. This improvement is made more significant by learners in the experimental group attaining a lower average score for the pre-quiz and a higher average score for the post-quiz than the control group, as they started with less prior knowledge upon which to build and yet outperformed the control group in the post-quiz.

The effect size in Fractions 2 and 3 was too small from which to draw any meaningful conclusions, meaning that there was no notably difference in performance between the control and experimental groups. While the difference in improvement in Fractions 3 was insignificant, the experimental group scored significantly higher for the pre-quiz and the post-quiz. This is most likely attributed to learners' prior knowledge and the role it played in their completion of this lesson.

In Fractions 4 the learners in the experimental group again showed more improvement than learners in the control group, and their average pre-quiz and post-quiz scores were also significantly higher than those of the control group. This could point to this group of learners being academically stronger than the learners in the control group.

The effect size in Fractions 5 was too small from which to draw any meaningful conclusions, meaning that both the control and experimental groups benefitted similarly from watching the videos in English and English and isiZulu respectively.

In Fractions 6 the control group showed more improvement than the experimental group; however they ended with similar post-quiz scores. In consultation with the quality assessor, she said that she could not find any reason in the experimental video for the learners to not perform well because of it. The difference in improvement could then be because the experimental group scored higher than the control group in the pre-quiz. If the experimental group were to then show as much improvement as the control group (i.e. if they were to improve 37.25% by 26.41% points) it is unlikely that either group would attain an average of 66.33% for this post-quiz. As such the lesser improvement shown by the experimental group is most likely attributed to the high scores attained in the pre-quiz, rather than video quality.

In Fractions 7 the learners in the experimental group scored lower in the pre-quiz, indicating they had less existing knowledge of the content prior to watching the video. These learners also scored on average lower than the control group for the post quiz. However, they showed more improvement than the learners in the control group. The reasons for this are unclear.

If it is the case that all (or most) learners have meta-cognitive awareness (i.e. they're aware of what they know and what they don't know) then one may assume that the learners who selected to do the English-medium course either did so because they were confident in their English proficiency, or because they were not confident in their isiZulu proficiency because it's not their L1, or they were willing to compromise their understanding of mathematics in pursuit of English proficiency. However, the learners' awareness of how they would be perceived and treated by their peers based on their choice of LoLT for the Fractions course should also be taken into account.

5.2.3 Glossary usage

The findings of the bilingual online glossary usage 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 for 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 reversioning of the term. Another likely reason is that putting an answer into *simplest form* makes the difference between an answer being correct or incorrect, whether or not the concepts have been understood and all other processes have been followed. For this reason, learners may have clicked on it many times to check that they would or had done the correct procedure to get an answer that the computer would mark as correct. Furthermore, the term *simplest form* also occurred significantly more often throughout the course than the other glossary items, and its frequent appearance could also be a contributing factor to its repeated clicks. Learner 2, who clicked on this term the most times, defined it with the isiZulu term *ezilula kakhulu*. Eight out of the 14 learners who took the quiz gave definitions that indicated they understood the concept.

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.

IsiZulu and isiXhosa-speaking learners wrote in their L1s more readily than had ever been noted in a written task at OLICO Youth. 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: 127) 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: 287) 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.

5.2.4 Feedback during the course

The feedback collected from the learners during the course is important as it's often in the unstructured feedback like this where learners let their guard down and are honest, because they don't feel like they're being tested. However, due to the online nature of the course, off-the-cuff feedback about the experiment was not easy to come by as online work typically cuts down interpersonal interactions and discussions.

As argued by Cummins and Swain (1986: 101), the use of the learners' L1 asserts their pride in their identity, and as argued by Benson (2004: 119) 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.

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.

The quality assessor's feedback about the ambiguity of using the term *izikhathi* to reflect fractions speaks to Pimm's (1981: 148) 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 regarding ambiguities of the language used and correctly explaining core tenets of the subject were vital in this process, and suggests that if this model of codeswitching were to be applied elsewhere it would require the person creating 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 raised by Setati et al. (2002: 135), learners need to be familiar with the associated discourse of any subject in order to be able to make sense of it. In this case learners are only familiar with this discourse in English, and the equivalent discourse in their L1 is resultantly unfamiliar. The quality assessor (interview: 2015) supports this argument by pointing out that learning mathematics in their L1 is unfamiliar for the learners in this experiment and thus they would require more time and exposure to it in order to be familiarised with it.

5.2.5 Parent discussion group

There are many conflicting attitudes towards learning through the L1 in South Africa. Without parents' support, any education programme will be hard-pressed to be successful. It is therefore encouraging to note that the parents made no allusion to the belief that African languages should not be used as LoLT because they are inferior or lack necessary terminology, a belief that Probyn (2009: 127) notes is commonplace in South Africa. The parents held differing views about whether or not English should be used as a medium because it is the language used at school (and by extension in the political economy), or whether translanguaging should be implemented because it assists with cognition. This illustrates the tension noted by Webb, Lafon, and Pare (2010: 280) that the utility and prestige of English often outweighs the cognitive benefits of additive bilingualism.

Thinking that "literacy" refers to "English" reinforces the idea that African languages are not for the academic world – they are something for the home. Parents' views on the importance of learning English reflect the usefulness of English, and the necessity of understanding it if one is to succeed at school. In answering the question of whether it is important to learn in English, parents approached this in a very practical way, looking at the current educational context their children are in, rather than in an idealistic way which would challenge the current LoLT norms.

Parents' enthusiasm for their children to learn African languages reflects a strong tie to cultural identity, and possibly also parents' concern that urbanisation, globalisation, or the hegemony of English might diminish their children's knowledge and practice of their culture.

The parents' views are important because they determine to a large extent how supportive the parents will be of their children participating in a multilingual programme. Their views are also important because they represent views that are informed by their surrounding society and personal convictions, rather from being learned in academia in this respect. Alexander (2000: 13) wrote about recognising the sentimental value of a language and understanding the relationship between language and cognition, and the parents involved in this discussion value language for both these reasons. The parents clearly value their home languages for sentimental reasons, citing the connection between language and culture. While the parents also value language for its facilitation of cognition, this is slightly more complex: parents are very conscious that their children understand content better in their L1s, however there was no allusion to the cognitive benefits of developing one's L1. It was particularly encouraging that the suggestion of using English and learners L1s was brought forward by a parent.

It is encouraging to see such forward-thinking parents. The literature suggests that it is currently difficult to implement policies of true additive bilingualism because of parents' resistance towards such policies. Hopefully with more parents like this it will become easier to implement better language policies. However, as Setati and Adler (2000: 254) suggest, parents from urban areas are more open to codeswitching than parents from rural areas. As such it may be the case that the parents present in this discussion represent urban parents to a larger extent than rural parents. Even if this is the case, parents' views are critically important as they largely determine to what their children will have access.

5.2.6 Pre-course surveys

As illustrated in the data presentation, the main reasons learners selected *No* in answer to whether they would like to watch videos in their L1s was that their L1 is difficult, it is important to learn English, English is the LoLT, English is a lingua franca in a multilingual environment, and that they prefer English to their home language. The reason that learners gave when saying that their L1 is difficult also alludes to the belief noted by Probyn (2009: 127) that appropriate terminology for mathematics in African languages does not exist. It is noteworthy that these learners felt their L1 to be more difficult than English, yet when they conversed with each other (be it in a BICS or CALP context) they generally used their L1, with small amounts of English thrown in now and again. This was also the case when they explained mathematics to each other, except for when they were reciting rote procedures for which they use English.

Upon interrogation of some learners I discovered that when they think about learning through their L1 they imagine the type of L1 they are taught as Home Language at school. This is typically very formal language with a focus on form rather than meaning. The argument for English as a lingua franca in the multilingual environment certainly makes sense, however in reality this is not practiced by the learners as they use either isiZulu, Sepedi or Sesotho as lingua francas amongst each other, selecting one of these languages depending on the L1s of the conversation participants. At OLICO Youth, English is only truly used as a lingua franca with facilitators, and several learners still use their L1 to communicate with the facilitators (myself included, despite learners' knowledge of my limited multilingual proficiencies).

Learners' argument for the importance of using English is hard to refute, and in conversations with learners it often comes across that being fluent in English is synonymous with being successful. In this regard it is likely that learners choose to learn in English (a) because they believe it will help them to become more fluent in English, and (b) because learning in English holds a certain level of prestige on its own.

As illustrated in the data presentation, the main reasons learners gave for selecting *Yes* in answer to whether they would like to watch videos in their L1s was that the English language is difficult, that they understand better in their L1, and that they prefer using both English and their L1. In this case it is clear that learners prioritise understanding content above all other factors. The learners' metacognitive awareness here is noteworthy, as the learners have chosen an option that they most likely know is not as prestigious, yet they seek understanding rather than prestige. It is noteworthy that one learner suggested mixing languages, suggesting she recognises that she understands her L1 better than English but also that it is important to use English in this context (which she could have attributed to a number of reasons discussed above).

The learners found the videos ranging from "ok" to "very easy", but found the mathematics to range from "difficult" to "very easy". Working on the premise that the videos assist learners in understanding the mathematics, these results suggest that there is a slight mismatch between the videos and the mathematics, and that learners were not feeling fully equipped for the mathematics after watching the videos. On the other hand, watching a video is a relatively passive act and doing mathematics is active, so naturally some learners may find watching the videos to be easier tasks than actually doing mathematics.

Before the experimental course, the majority of learners stated that they would not prefer to watch the videos in their L1. It is regrettable that the question was phrased in this binary way because, judging from learners' comments, they value English for its function and prestige and so would generally not choose English over their L1. However, they may still have been open to including their L1 in addition to English had they been given this option in this question. That said, it is noteworthy that learners theoretically chose the function and prestige of English over the comprehensibility of their L1s.

5.2.7 Discussion groups

It is of interest that the learners stated that they prefer the videos in both English and their L1, as this was before the Fractions course was made available in this form, and so learners had taken it upon themselves to lobby for this. This indicates some learners already believed that this would be beneficial for them.

Learners made reference to the "step-by-step instructions" and that the video "shows you how to do it". This likely indicates that these learners feel the most helpful part of the videos is the procedural knowledge they impart. However, it could indicate that the videos progressed conceptually in an order that made sense to the learners. On the other hand, several learners made reference to how the videos "help us to understand" thereby indicating they gain conceptual understanding. Also "they show how to calculate methods" suggests that learners understand the videos as assisting them with procedures.

5.2.8 Post-video interviews

These interviews speak to the point made by Moschkovich (1999: 27) that researchers should also examine how learners solve mathematical problems rather than simply looking at their ability to do so.

The first learner I interviewed did not point out anything about the experimental course of her own accord, but when questioned about it she stated that she now understands the videos and, if given the choice, would still choose to learn with isiZulu again. This illustrates that while learning through isiZulu is not noteworthy to her, she does prefer it from an understanding perspective in comparison to learning in English.

The reaction of the second learner I interviewed when I asked her to explain to me indicates that this is a new thing for her to do. While it is quite common in urban South African schools for teachers to ask learners to explain how they did something so that they could see their thought process and conceptual development, this was clearly new for her, indicating that this is lacking from her education both at school and at OLICO Youth.

In these interviews it is evident that learners' explanations are procedural, with limited – if any – conceptual explanation involved. This may be attributed to the school environment which, according to the literature (see for example Pretorius and Machet, 2004: 57) and supported by observations made by my colleagues and myself, is heavily procedural. In addition to this, the course and videos in which learners participate at OLICO Youth also revert back to procedural approaches to an extent, in that learners are assessed by their answers and that there is no room for discussion of concepts in the online classroom setting. Furthermore, the videos illustrate that the procedures and methods learnt by the learners at school are often deeply ingrained in their approach to mathematics, as several learners used methods they had learnt at school rather than using the methods they had learnt in the OLICO videos. This also shows us that while the learners are gaining something from the videos, the course is partly simply providing them with practice activities which allow them to improve their procedural methods and make them more accurate. That said, it is insufficient to simply add bits of learners' L1 here and there in some videos and hope for a miracle. The programme itself needs to break down the rote approach learners are so comfortable with (although how to do this is beyond the scope of this research) and provide more focus on conceptual development through the videos and coursework. Perhaps then a concept-based translanguaging model could be more useful. However it is clear that while language proficiency is a notable factor in education it is certainly not the only factor at play.

5.2.9 Post-video Surveys

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: 62) point that additive bilingualism also fosters learners' embrace of other cultures. It is worth noting that the control group found Fractions easier in comparison to the experimental group, and that the experimental group found Fractions easier than Decimals. This could be because the experimental group was confused or disoriented by the use of isiZulu, or because the experimental group had enhanced metacognitive awareness during the isiZulu-medium course and were more aware of what they did not know than the control group.

5.2.10 Post-video discussion

There are two main ideas evident in the post-video discussions. Firstly, it is clear that either (a) learners' enthusiasm for learning through English together with their L1 had diminished after the completion of the course, or (b) the learners who felt this way were more confident and forthcoming with feedback than those who did not. This is likely because learners are constantly surrounded by and aware of the prestige of the English language. Secondly, it is also clear that learners were enthusiastic about creating videos in several languages. This again reflects Lindholm's (in Lindholm-Leary, 2001: 62) note about cultural acceptance being created through additive bilingualism.

5.3 Conclusion and implications

As is expected in DBR, it is very difficult to maintain a sterile, controlled environment in the classroom context. This is exacerbated by working in an after-school enrichment programme. It is difficult to get all types of data from the same learners, as often learners will be present for one data collection and absent for another. This has the potential to skew the results, particularly with such a small sample group. This is also the case with the mathematics course with different learners doing the different lessons.

It would appear that many of the learners are, to an extent, semilingual. As described by Baker and Hornberger (2001: 40), the learners have been brought up multilingual but have not been afforded the opportunities to become fully proficient in any of these languages; in particular they do not appear to fully develop their CALP.

The implications of these findings are that translanguaging combined with technology is a useful tool for increasing learners' perceptions of their L1 and for increasing their language proficiencies. These implications need not be limited to technological interventions: if teachers were to employ a translanguaging methodology similar to that used in this experiment they may be able to achieve similar results, although of course this would need to be carefully evaluated as the traditional classroom differs quite significantly from a blended learning classroom.

Chapter 6: Recommendations and Conclusions

6.1 Conclusions of the research

This research began by outlining an important problem in South Africa: the language used in our education system is failing its learners. The reality and severity of this problem was supported by various studies regarding both national and local contexts.

Socio-political considerations were discussed, and the tension between language policy and learners' lived language proficiencies was elaborated on. Linguistic and mathematical considerations were discussed with specific reference to codeswitching and the subject of fractions, the relevant strand of mathematics, respectively. Personal considerations were noted, particularly that one's language is inextricably linked to one's sense of self.

The methodology for this research was design-based research. This methodology was outlined and its relevance explained. The methods used to implement and analyse the experiment were listed.

The findings of this research were that the experiment did not show significant quantitative results because of the short time frame and small number of participants. Qualitatively it showed that many learners had increased enthusiasm about bilingual learning while the course was running, but soon reverted back to the desire to learn through English once this was the only option for them again. The fact that learners felt like their languages, and by extension their persons, were valued cannot be understated.

Learners' attitudes towards the languages used in education tended to reflect what they experienced: when they were learning in English they said that they wanted to learn in English, and when they were learning bilingually they said that they wanted to learn bilingually. While I would often speak to learners about the benefits of learning through one's L1, these conversations were informal, brief, and did not include all learners or full discussions. It would have been helpful, and indeed for future iterations of this design experiment it may be useful, to engage more purposefully and regularly with learners on the benefits of incorporating L1 in learning. Furthermore, it would be useful to engage with learners, parents and teachers throughout South Africa on the benefits of incorporating L1 in learning. It is through these discussions that it may become possible for learners' L1s to successfully be incorporated in their learning.

A limitation of this research of which I was keenly aware was my own language proficiencies. My L1 is English; I have an intermediate understanding of isiXhosa after studying it as a non-mother tongue at university for three years; and I can understand isiZulu insofar as it is mutually intelligible with isiXhosa, with this understanding further limited by my isiXhosa limitations. I recommend that for further iterations of this design experiment the researcher should be fully bilingual in both languages being used in the course, or else the researcher should work extremely closely with a fully bilingual research assistant. Further exploration of the video and glossary reversioning quality would also add to the evaluation of this research. This limitation was, however, greatly alleviated by the team with which I was working on this research.

South Africa, with its 11 official languages, has many different language contexts, and there is no one-size-fits-all solution to the research problem. I recommend that further iterations of this experiment be carried out in different South African contexts, for example a context where learners' L1 is more homogenous and their access to English is more restricted. This may then facilitate tailoring multilingual education interventions that can then be replicated throughout different contexts in South Africa.

6.2 Broader conclusions

When considering the broader context the findings of this research have multiple implications. It would appear as counter-intuitive that an experiment informed by relevant literature, experience and observations did not show significant quantitative results. However, when considering the other factors involved this begins to make more sense. Firstly, because the learners in this study are learning in multilingual urban environments they are more likely to experience more English exposure at school than learners from rural environments. This means they probably have better-developed English proficiencies than learners in rural areas. This also means that these learners are less accustomed to learning through their L1, and would likely require time to adapt to this. The very short time frame of this experiment did not allow for this to be explored to its fullest. Furthermore, this research shows that while accessible language is vital in creating quality education for all, it is not sufficient. When considering the subject matter taught in this experiment, and also considering how much subject matter is taught throughout schools in South Africa, it is imperative that there is a move away from purely procedural teaching and learning where a correct outcome is the only goal, to including conceptual development where understanding of the processes and the concept is emphasised.

6.3 Implications

The findings of this research suggest that further research is imperative if this first iteration of the experiment is to be optimally useful. In creating further iterations it would be highly beneficial to create similar experiments in different contexts in South Africa; in urban and rural contexts, and in multilingual and monolingual contexts. This would allow for the experiment to be adapted to the 'foreign language learning' and 'second language learning' contexts of South Africa.

Once the theoretical codeswitching framework is refined through further iterations of the experiment in different contexts, it would be highly beneficial for this codeswitching model to be workshopped with teachers so that teachers and learners may be empowered through successful codeswitching in the classroom. This could be further realised through the creation of similar multilingual supplementary materials.

6.4 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 large quantitative results, the qualitative results illustrated learners' improved motivation to learn and 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.

By incorporating learners' L1 in 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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Appendices

Appendix A

Colour-coded scripts: English

Fractions Lesson 8: Multiplying fractions

Blue is slide heading
Green is isiZulu
Orange is English

Slide 1: Coloured-in rectangle
We're going to have a look at multiplication of fractions today. We're going to start with having a look at the logic, and then we're going to see how we can do it nicely and easily. Let's say I have a cake, and I've decided to give you two thirds of my cake. What do I do? I cut it up into three pieces, and I give you two of them. So there's your two thirds nicely in green. You're feeling generous, and so you decide that you are going to give half of that two thirds that you've got to your little brother. So let's think about what you'll give to your little brother. What you will need to do is cut that in half, so that you can then say, ok, this bit's going to my brother, and this is the bit that I get to keep. Let's have that picture nice and neatly so we can talk about it.

Slide 2: Coloured-in rectangle with dark green
So half of two thirds will be this dark green portion over here. So half of two thirds, we can see quite easily, is one, two pieces, out of one two three four five six pieces, so it is two over six. In other words, one half of two thirds gave me two sixths. We can see easily how to get that answer; one times two is two, and two times three is six. So multiplying fractions is very easy, you just multiply the numerators together, and multiply the denominators together.

Slide 3: ¾ x 5/7
Ok. So now we know how to do it, we can just get the answers straight away. What is three quarters times five sevenths? Well, we multiply the numerators, three times five gives me fifteen, and we multiply the denominators and we get four times seven which is twenty-eight. We now see if this thing can be simplified at all. Well, no it can't actually, because fifteen is just made up of five times three, and three won't go into twenty-eight, and nor will five. So fifteen over twenty-eight is as simple as it gets. Ok, I want you to open your homework book, and there is this example there that you need to try.

Slide 4: 3/5 x 2/9
Three fifths times two ninths. Pause the video now and do it quickly in your homework book and we'll discuss it later. Ok. So the simple way is just to say three times two is six, and five times nine is forty-five, and now I've got to go and simplify that. Well I can actually see there is something that can go into both of these. Three can go into both of these. So if I divide the top by three I get two, and if I divide the bottom by three I get fifteen. In other words, I'm doing the same to top and bottom, divide by three divide by three, and I get two fifteenths which is my simplified version. Now, if we're clever, we can actually avoid quite a lot of extra work. Because, if we cancel before we multiply, we will end up not having to do nearly as much simplification, and believe me sometimes the multiplying you will have to do will end up being really big horrible numbers unless you do the simplification. So let's have a

look at exactly this problem again, but let's do it more cleverly. If we have three over five times two over nine, we know that what we have to do is we have to multiply the numerators together, and then multiply the denominators together. But we also know that when we have a fraction like this, what we do to the bottom, divide or times, we also do to the top, divide or times by the same thing. And let's have a look right here where we are. Before I've done anything I can see that I've got a three on the top, and a nine on the bottom, both of them can be divided by three. So I can go and say, divide the top by three, that'll just leave me with a one, and divide the bottom by three, that will leave me with a three. So I've got no problems, I'm doing exactly the same to top and bottom of my fraction, so I'm not changing anything. Then I get, one times two is two, five times three is fifteen, and I get my answer of two fifteenths. So the idea there is just to do your simplification before you do your multiplication because that'll make it easier and quicker. Let's look at an example like this.

Slide 5: There are 24 learners in my class. ¾ of the learners are girls. How many girls are in my class?
There are twenty-four learners in my class. Three quarters of the learners are girls. How many girls are there in my class? Well I know that three quarters of the twenty-four are girls. In other words what I need to do is, three quarters multiplied by twenty-four. Now you should remember that I can write any whole number as a fraction by just putting it over one. Twenty-four over one is the same as twenty-four, just like five over one is five, a hundred over one is the same as a hundred, and a million and twenty-three over one is the same as a million and twenty three. So we're back in the same situation that we've been in. So we can multiply numerators together and we can multiply denominators together and get our answer. Here's one of these examples where if we actually just do the multiplication we're going to end up with a nightmare. Three times twenty-four is a big calculation to do. So let's go with my idea, let's just say we've got three times twenty-four, over four times one. Now before we actually go and do all that tedious multiplication, let's see if we can cancel, because that'll make it simpler. I notice that I've got twenty-four at the top and four at the bottom. Four can divide into both of them, and our rule for fractions is as long as I multiply or divide the top and the bottom by the same thing, I haven't changed the fraction. So let's divide through by four. That'll give us one. Divide this by four, that'll give me six, and now I can get my answer without having to do my nightmare calculation. Three times six is eighteen, and one times one is one, so I get my answer of eighteen over one, and of course eighteen over one is just the same as eighteen.

Slide 6: 3 2/3 x 3 2/5
Ok. If we need to do a multiplication and we've got mixed numbers, my same rule for mixed numbers applies: just turn them into improper fractions and then you'll be fine. Ok, so let's turn these into improper fractions. Three threes are nine, plus two gives me eleven over three. And two and two fifths, two fives are ten plus two gives me twelve, so I have got twelve fifths. Again, big calculations if I don't do any simplification first; I'd have to do eleven times twelve and three times five and then go and see if I can simplify at the end. It's much easier if I do it first like this: I say eleven times twelve over three times five and I see ok, can I divide top and bottom by the same thing and I see yes, I can immediately see I can divide top and bottom by three, that goes once, that goes four times, and so I will get eleven times four is forty-four, and five times one is just five. And if I want to turn that back into a mixed number I say five goes into forty-four eight times with four remaining, so that's eight and four fifths.

Slide 7: Blank slide

Ok. Try quickly for yourself, this is in your homework book for you to try, do two and one third multiplied by one and two sevenths. Pause the video now and do it, and then we'll check it together. Ok you should have got the following. Seven over three, two threes are six plus one is seven, multiplied by seven times one is seven plus two is nine so that's nine sevenths. Let's just see if we can simplify before we continue. Well this is a great simplification right? We can divide top and bottom by seven and we can divide top and bottom also by three. And so our answer ends up being, one times three is three, one times one is one, three over one, and of course we know that three over one is just three.

Appendix B

Colour-coded scripts: English-isiZulu bilingual

Fractions Lesson 8: Multiplying fractions (English-isiZulu bilingual)
Blue is slide heading
Green is isiZulu
Orange is English

Slide 1: Coloured-in rectangle
Namuhla sizofunda uku Multiplier ama fractions. We're going to start with having a look at the logic, and then we're going to see how we can do it nicely and easily. Ake sicabange ukuthi mina ngine Khekhe, ngifuna ukukupha u two third we khekhe. Lokhu kuchaza ukuthi ikhekhe kumele ngiliqhephule libe iziqephu eziyi three bese ngikhuphe iziqephu ezimbili. Nazo iziqephu zakho ezimbili zivezwe ngombala o dark green. Masithi uzizwa unomusa bese ufuna ukupha umfowenu u hafu ka two thirds we khekhe engikuphe lona. Lokhu kuchaza ukuthi kuzomele ulisike esiphakhathi khona nizo thola iziqephu ezilinganayo.

Slide 2: Coloured-in rectangle with dark green
U half ka two thirds yileziqephu ezi dark green. U half ka two thirds siyabona kalula ukuthi iziqephu eziyi one, two kweziyi six ezikhona. Ngamanye amagama u half ka two thirds ukupha u two sixth. Kulula ukuthola lokhu ngoba sithi one times two usipha u two, u two times three usipha u six. So multiplying fractions is very easy, you just multiply the numerators together, and multiply the denominators together.

Slide 3: ¾ x 5/7
Ok. So now we know how to do it, we can just get the answers straight away. What is three quarters times five sevenths? siMultiplier ama numerator wodwa u three times five usipha u fifteen ama denominator wodwa u four times seven usipha u twenty eight, impendulo yethu ivele ibe u fifteen over twenty eight. Angeke sikhone uku simplifier ngoba u fifteen wenzwa u three no five kanti zombili lezi number angeke zikhone uku divideka ku twenty eight. So fifteen over twenty-eight is as simple as it gets. Ok, I want you to open your homework book, and there is this example there that you need to try. Mangi divide ngo three phezulu ku numerator nango three ku denominator . Siyakhumbula ukuthi umtheto wama fractions uthi uma u multiplier noma u divide phezulu kumele uwenze okufanayo nangezansi. Sizothola u two fifteens.

Slide 4: 3/5 x 2/9
Three fifths times two ninths. Pause the video now and do it quickly in your homework book and we'll discuss it later. Ok. So the simple way is just to say three times two is six, and five times nine is forty-five, and now I've got to go and simplify that. Ngiyabona ukuthi ikhona i numba engangena kulezi number ezimbili ku six naku fourtyfive. Three can go into both of these. So if I divide the top by three I get two, and if I divide the bottom by three I get fifteen. In other words, I'm doing the same to top and bottom, divide by three divide by three, and I get two fifteenths which is my simplified version. Manje masihlakaniphile sizobona ukuthi singazafulela umsebenzi omningi ngoku khansela sicale nge simplification ngaphambi koku multiplier, ngoba kwesinye isikhathi ukucala nge multiplication kuzosinika izinamba ezinkulu ezokwenza umsebenzi wethu ube nzima. Asibeke isibalo sethu ngendlela ehlakaniphile manje, uma sino three over five times two over nine. Let's do it more cleverly. If we have three over five times two over nine, we know that what we have to do is we have

to multiply the numerators together, and then multiply the denominators together. Okusele ukuthi si Multiplier ama numerators wodwa bese si multiplier ama denominator wodwa, kodwa siyakhumbula ukuthi kule fractions uma si multiplier noma si divide phansi kumele senze okufanayo phezulu. Asibone ngaphambi kokuthi ngicale ngiyabona ukuthi ngino three phezulu no nine phansi. Ngizovele ngidivayide u three ngo three ngisale ngo one, bese ngi divide u nine ngo three ngisale ngo three. Ayikho inking ngoba i number eni divide ngayo phezulu ngenze okufanayo ngezansi lokhu futhi akushintshi sibalo sethu. Ngisala no one times two ngithola u two, five times three ngithola u fifteen . impendulo yam ivele ibe u twofifteens. Okusemqoka lana ukuthi ngaphambi kokuthi wenze i multiplication , kumele ucale ngokuthi u simplifaye ngoba lokhu kwenza umsebenzi wakho ube lula futhi uwenze ngokushesha. Asibone esinye usibonelo. Then I get, one times two is two, five times three is fifteen, and I get my answer of two fifteenths. So the idea there is just to do your simplification before you do your multiplication because that'll make it easier and quicker. Let's look at an example like this.

Slide 5: There are 24 learners in my class. ¾ of the learners are girls. How many girls are in my class?
There are twenty-four learners in my class. Three quarters of the learners are girls. How many girls are there in my class? Ngiyazi ukuthi u three quarters ka twenty-four amantombazane. Kafushane engikudingayo u three quarters times twenty-four. Khumbula ukuthi ngingabhala i whole number noma yiphi ngiyenze i fraction ngoku divida ngo 1. Twenty-four over one is the same as twenty-four, just like five over one is five, a hundred over one is the same as a hundred, and a million and twenty-three over one is the same as a million and twenty three. So we're back in the same situation that we've been in. So we can multiply numerators together and we can multiply denominators together and get our answer. Here's one of these examples where if we actually just do the multiplication we're going to end up with a nightmare. Three times twenty-four is a big calculation to do. So let's go with my idea, let's just say we've got three times twenty-four, over four times one. U three times twenty-four uzosipha I number enkulu. Asisebenziseni iqhinga loku khansela si simplifier lokhu kuzokwenza ukuthi izinto zibe lula. I notice that I've got twenty-four at the top and four at the bottom. Four can divide into both of them, and our rule for fractions is as long as I multiply or divide the top and the bottom by the same thing, I haven't changed the fraction. So let's divide through by four. That'll give us one. Divide this by four, that'll give me six, and now I can get my answer without having to do my nightmare calculation. Three times six is eighteen, and one times one is one, so I get my answer of eighteen over one, and of course eighteen over one is just the same as eighteen.

Slide 6: 3 2/3 x 3 2/5
Ok. Masi multiplier ama mixed fractions, umthetho uthi ngaso sonke isikhathi washintshe ama mixed fractions uwenze abe ama improper fractions. Ok, so let's turn these into improper fractions. Three threes are nine, plus two gives me eleven over three. And two and two fifths, two fives are ten plus two gives me twelve, so I have got twelve fifths. Ngizithola ama number amakhulu, I'd have to do eleven times twelve and three times five and then go and see if I can simplify at the end. It's much easier if I do it first like this: I say eleven times twelve over three times five and I see ok, ikhona yini I number enga divida ngayo phezulu nagezansi kwe fraction? I yebo ikhona. I can immediately see I can divide top and bottom by three, that goes once, that goes four times, and so I will get eleven times four is forty-four, and five times one is just five. Uma ngifuna ukuyibuyisela kwi mixed fraction I say five goes into forty-four eight times with four remaining, so that's eight and four fifths.

Slide 7: Blank slide

Ok. Try quickly for yourself, this is in your homework book for you to try, do two and one third multiplied by one and two sevenths. Pause the video now and do it, and then we'll check it together. Ok you should have got the following. Seven over three, two threes are six plus one is seven, multiplied by seven times one is seven plus two is nine so that's nine sevenths. Let's just see if we can simplify before we continue. Well this is a great simplification right? We can divide top and bottom by seven and we can divide top and bottom also by three. And so our answer ends up being, one times three is three, one times one is one, three over one, and of course we know that three over one is just three.

Appendix C

Winter School questionnaires (volunteers' copies)

Group name: ______________________ Grade: ________

Group members: ______________________
____
____
____
____
____

olico

Questions about OLICO videos

How easy are the videos?

Comment **Name**

______________________________ ____________
______________________________ ____________
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______________________________ ____________
______________________________ ____________

How easy is the maths you do at OLICO?

Comment **Name**

______________________________ ____________
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______________________________ ____________

Would you prefer to watch the videos in your home language?

Comment **Name**

______________________________ ____________
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______________________________ ____________
______________________________ ____________

Appendix D

Permission forms

RHODES UNIVERSITY
Where leaders learn

30 June 2015

Dear parent/guardian,

Master's research at OLICO Youth: Permission form

My name is Nathalia von Witt and I am the Literacy Coordinator at OLICO Youth. I am doing my Masters research in African Language Studies through Rhodes University, with a focus on language and education.

This letter is to ask for your permission for your child to be included in my research. I would like to use your child's experience and results of the OLICO Youth Maths course in my Master's research. I will not be using your child's real name in my research, and so the identity of your child will be protected.

At OLICO I am always looking for the best ways to help your child improve their Maths. I believe that it is easiest to learn in your home language, and I also know that it is important to be able to learn in English.

Next term we will be introducing a new course at OLICO: learners may choose to do their Fractions course in English and isiZulu together. We hope that this will help them understand the Fractions work and also improve their English.

If you would like to know more about my research or what I am doing at OLICO please feel free to visit me at OLICO or contact me on 0110749669.

Please sign the following declaration and return it to Nathalia or Khotso at OLICO by Friday 3 July 2015.

I, ______________________________(your name and surname),

parent/guardian of ________________________ (your child's name and surname).

- ☐ give permission for my child to do the English and isiZulu Fractions course

  AND/OR

- ☐ give permission for my child to be included in Nathalia's Master's research project

} please tick to give permission

I understand that my child's identity will not be disclosed in the research.

Signed: ________________________ Date: ________________________

Many thanks,
Nathalia von Witt
(011) 074 9669
nathalia@olico.org

This research has been approved by the Research Committee of African Language Studies Section of the School of Languages, Rhodes University, Grahamstown. Should you require further clarification you can speak to my supervisor Dr Pamela Maseko (p.maseko@ru.ac.za) or Dr Dion Nkomo (d.nkomo@ru.ac.za)

Appendix E

Feedback from the quality assessor

Lesson 1: Introduction to Fractions

Generally the lesson is very sound. Just a few things to take into consideration:

1. When referring to the 6 ‘fizzers’ in different colours, Thabiso needs to make an emphasis on the whole, so that the learners can understand that the ‘fractions’ did not just come out of nowhere. When I was teaching grade 5 learners I discovered that most of the time they would not relate the parts to the whole which is the essence of fractions.
2. I think the sequencing of example space needs to be considered for example, the first ‘fizzer’ in orange is a whole which is 1/1, then the second (green) is 1/3 then purple is 1/6…and so forth. I would suggest for the sake of coherence in example space that there is a flow –similar to the structure of the fraction wall in the second lesson/video. Also learners are quite familiar with ‘half-1/2’ and it would be the best example to build onto.
3. In terms of the language (Zulu), there needs to be caution of ambiguity that can confuse the learners, for example when explaining how to divide 6 parts to 6 children equally- what is written in the first box is ‘Iziqephu umfundi azitholayo, uma sehlulwa izikhathi eziyisithupha’. The word ‘izikhathi’ here means ‘times’. It would be best to stick to the word ‘iziqephu’ (parts), also there is need to reference the ‘whole’ in this statement/explanation which means this statement could be rephrased as ‘ Iziqephu umfundi azitholayo uma ifizzer ephelele (whole fizzer) ihlulwa iziqephu eziyisithupha’.

Lesson 2: Comparing Videos

For the purpose of coherence, the lines being drawn to divide the two wholes into parts should be aligned. For example, first divide the first whole in half, then the second into half as well making sure the line aligns with the line in the middle of the first whole (on top), then divide the two halves in the middle to now make 4 x ¼. Look at the picture of the example of 1/6 vs 1/3 for reference. This will be helpful for later in that learners will be able to see that a half (1/2) is equal to two quarters (2 x ¼)

Lesson 3: Equivalent Fractions

1) My comment here is related to coherence in example space. I think it’s best to start with the second block in the fraction wall which is ½ again, it’s easier for learners to work with a ½ and then build up.
2) Where T is comparing the equivalent fractions 1/3=2/6=3/9 etc, T has written ‘Amaqhezu alingayo’ Language here again needs to be precise because ‘alingayo’ can mean something else, so it should be ‘Amaqhezu alinga<u>**na**</u>yo’, I understand this could just be an error, but we just need to be cautious that the mathematical meaning is not lost.

<u>Overall Comments</u>

Everything else is perfect. Thabiso is very good, very articulate, the pace at which he is explaining is perfect and he communicates very clearly and is mostly able to project the mathematical meanings.

Appendix F

Learner interviews transcribed

Learner interviews conducted 21 August 2015

<u>Learner 1</u>

NvW: This is for you to tell me about the Fractions course, and I want you to tell me everything. All the good things, all the bad things. Ok? So I'm going to ask you a few questions and then you can tell me what you think, ok? So first, did you learn anything new in the Fractions course?

L: Yes.

NvW: Did you learn stuff you hadn't already learnt at school? Had you learnt everything at school, in the Fractions course?

L: Yes. Some ones we, we do at school, but some we didn't.

NvW: Ok, which ones didn't you do? Do you remember?

L: Yes.

NvW: Ya?

L: That, hmm, that of they gave me one and three over four times two four over five.

NvW: And that one you didn't do at school before?

L: Yes.

NvW: And how was that, was that easy or difficult?

L: Easy.

NvW: Easy? What made it easy?

L: Because now I understand it. First I didn't understand because they gave me, first they gave me skills practice for one attempt, so I got one answer, so they gave me video, so I repeated, repeated, until I understand it.

NvW: Ok, very nice. So you repeated the video until you understood?

L: Yes.

NvW: Very nice. What was the most difficult thing that you learnt in the Fractions course? Can you remember?

L: No.

NvW: No, ok. Is there anything that's still difficult for you in the Fractions course?

L: No.

NvW: Is everything easy?

L: Yes.

NvW: Nice, and what didn't you like in the Fractions course? Was there anything that you really didn't like?

L: No.

NvW: Nothing? That's cool. And what did you like about the Fractions course?

L: All of things.

NvW: All of the things? What were you favourite things about the fractions course?

L: Um, that thing that I told you, the one over something.

NvW: Ya, you liked learning that? That's good. Was there anything else you liked or was that your favourite thing, learning that multiplication?

L: Mmm, and addition and subtraction that they give us.

NvW: Cool. And then were you doing the videos in Zulu?

L: Yes.

NvW: And how was that?

L: Good.

NvW: Is it? And if you have the choice to do it again would you rather do it in English or Zulu?

L: Um, it is right in Zulu because now I understand it.

NvW: That's cool, I'm very happy to hear that. And then the last thing that I want to do with you, can I ask you to do something for me? Alright so, what are you on at the moment? Where are you? You're on Fractions seven?

L: Eight.

NvW: Eight?

L: Eight. I'm done now.

NvW: Nice, very nice. Can I ask you to show me how you would do this one? This one over here, number 5. So can you do it for me?

L: This one?

NvW: Ya. Calculate three and five over six, minus, sorry it must look like this. Three and five over six minus one and two over 15. Can you explain it to me like I'm your little sister or your little brother, or your friend who doesn't know how to do it?

L: You're going to say three times six plus five, so, over six minus one – it's 15?

NvW: Ya.

L: One times 15 plus two over 15 so that we must, so we must check a lowest common multiple of, of fifteen and six is 30.

NvW: Yoh, very nice.

L: 30. So we're going to say three times six is equals to 18, 18 plus five is equals to 22, 22 minus 15 times one is 15 plus two is 17. So we come here. Here we do like this. 30, we're going to say 22 minus 17, we say two minus seven is impossible so we're going to borrow one here and one here will be 12. 12 minus, minus seven will be five. So here now is five. We've got to write, we can't say one minus one, now our answer is five, we're going to say five.

NvW: Very nice. Very, very nice. Yoh, so you've learnt a lot in this course hey? Cool. Is there anything else you want to tell me about the Fractions course? Anything, any comments, suggestions?

L: And now, they gave me another one on piri, pri squiz practice?

NvW: Ya, pre-quiz, pre-skills practice?

L: Yes. I like this one. They, they show me like, they will say five over ten of eight. So that I will say five over ten times 80 over one. So that I will say, I will say cancel will be one. Five will go how many, how many into 80? Will go eight times. So we're going to say five times eight will be 40. 40 over one, so will be now is 40 we're going to write it like this, is 40.

NvW: Yoh you've learnt so much hey. So what does this 40 mean, compared to that?

L: Um.

NvW: What is this question asking you?

L: They say change, eish, I don't know it now.

NvW: Ok, but you know how to do it which is great.

L: Yes.

NvW: Cool, thank you [name], that's all that I need to ask you.

Learner 2

NvW: The first question I have is did you learn anything new in the fractions course? Anything that you hadn't already learnt at school?

L: I had already learnt it.

NvW: Everything?

L: No. Erm, what you call, lesson 9 we didn't learn it at school.

NvW: What is that, the story sums?

L: Yes.

NvW: Alright. And then, was it easy or difficult, the course?

L: No, some were difficult some were not difficult.

NvW: What was the most difficult thing in the course?

L: 9.

NvW: 9? Why was 9 so difficult?

L: Because you don't know where you must subtract or add or multiple.

NvW: Ok that makes sense. Is there anything that is still difficult for you?

L: No, I understand now.

NvW: Nice. And then what did you, was there anything you didn't like in the fractions course?

L: No.

NvW: Are you sure?

L: Yes.

NvW: Ok and what did you like in the fractions course?

L: What did I like? Hmm. The way they teaching us to do, to calculate the methods.

NvW: Ok, and what's nice about that? What do they do to teach you that nicely?

L: They do it slowly so that you can understand it. If you don't understand you can get help.

NvW: Nice. Alright that sounds great. And then, what did you think of the Zulu course?

L: Ya it's great.

NvW: Is it? And then if you had the option what language would you like to be doing it in?

L: Setswana.

NvW: Is it? Is that your home language?

L: Yes.

NvW: Alright. Was it not difficult for you doing it in Zulu if your home language is Setswana?

L: No it's not difficult in isiZulu.

NvW: Ok cool. Then I want to ask you, so have you finished the fractions course hey?

L: Yes.

NvW: When did you finish lesson 8?

L: 8? Yoh. Last…

NvW: A while ago?

L: Yes.

NvW: Ok. Can I ask you then, can I ask you to show me how you would do this one, number 6, so you can write here, calculate two over three times twelve. But can you teach me like I'm your little brother or sister, so like I don't know how to do it.

L: Ha! Why?

NvW: Because I want to see how you can explain. So you know when you're stuck and Khotso or Thabiso explains, I want to see if you can also be a teacher like that and explain it. Do you think you can? Do you know how to do this?

L: Eh (yes in Setswana?), let's try. We say two over three times twelve over one equals, is only twelve and we can only multiply it by one.

NvW: Ok.

L: Yes. Then we want the lowest common multiples, multiple of 3 and 1. The lowest common multiple of 3 and 1 is 3. Then I say 3 goes how many times into 3 then it goes 1, then 1 times 2 is 2. Then 1 goes how many times into 3? It goes 3 times. Then 3 times 12 is 34. Then times 34. Then you say 2 times 34 is…

NvW: Is this the way they taught you to do it in the video?

L: No is the way we learnt at school.

NvW: Can you show me the method you learnt in the video? Do you still remember it?

L: Mm, I don't know, I was doing the method like this.

NvW: Oh, so you didn't do the method from the video you just did the one like this?

L: Yes.

NvW: And then you ended up with such big numbers. Was it not more difficult, or was it fine?

L: Difficult? No.

NvW: Is it?

L: Yes.

NvW: Ok. Alright.

L: I can, let me do this one. Yes, hey. Minus 13 over 4, then we say 3 times 4 plus 1 over 4, minus 1 times 4 plus 3 over 4. Then we say 3 times 4 is 12, 12 plus 1 is 13, then is 13 over 4 minus 1 then we say 1 times 4 is 4 plus 3 is, hey, is 7, that is 7 over 4. Then we say 13 minus 7 is 7, eh eh, 6, then equals to 6 over 4.

NvW: Cool, very nice. Alright and then that's all. Is there anything else you want to tell me about the fractions course?

L: No.

<u>Learner 3</u>

NvW: Are you finished the course now?

L: Yes.

NvW: Ok so you can tell me everything about it. My first question is, in the fractions course what did you learn in the course, was there anything that you hadn't learnt at school, or had you learnt everything at school before?

L: I did learn everything but I didn't know like how to use the methods. Yes.

NvW: Ok, so the course here even though you learnt it before it showed you the methods?

L: Yes.

NvW: Nice. What was the most, of the stuff you did here what was the most difficult thing? Do you remember? Maybe there was more than one. What was difficult in this course? You can't remember?

L: Yes.

NvW: Were there difficult things and you can't remember, or was it all easy?

L: There were difficult things.

NvW: Ok but you just can't remember right now. That's fine. And then was there anything that you still think is difficult from this course?

L: No.

NvW: Awesome. Cool. And then was there anything you didn't like in the fractions course?

L: No, I liked everything.

NvW: Ok, that's good. And then what did you like in the fractions course?

L: How to change an improper number to a mixed number.

NvW: Cool, why did you like that?

L: I found it very very easy.

NvW: Ok that's nice, I'm really glad. And then, were you doing the English course or the Zulu course?

L: English.

NvW: And why did you decide to do the English?

L: I can talk Zulu but I can't write it, I can't read it, I can only talk.

NvW: What's your home language?

L: Setswana.

NvW: That makes sense. So English is easier for you than Zulu?

L: Yes.

NvW: Then, the last thing I want to ask you, so you finished the course hey? So I want you to show me how you would do number 6. But I want you to show me, like pretend that I don't know how to do it, ok so maybe I'm your classmate or your little brother or your little sister, can you show me how you would do number 6 and explain it as you go?

L: Ok first you say 2 over 3 times 12 over 1, then you say how much does 3 goes into 12, 9, 12, it goes 4 times. Then which equals to 4, is 4 times. Then you said 4 times 2 which equals to 8 times 1 which equals to 8.

NvW: Nice, so that's nice and easy for you?

L: Yes.

NvW: Awesome. So then my last question for you, is there anything else you want to tell me about the fractions course? Comments, suggestions, anything?

L: It was easy but there were some things that were difficult, so I would choose the word, you can go for easy, because after you've learnt them you will get more information about how to do it.

Learner 4

NvW: Ok so here it's got that you're on fractions 7, are you still on fractions 7?

L: Yes.

NvW: So I'll just ask you a few questions about the fractions course, just so that I can get to know how it went, what you thought of it, if you have any ideas, alright? Was there anything that was in the fractions course that was new, that you hadn't done at school before?

L: Ya.

NvW: Like what?

L: Um, um, cross multiples.

NvW: Was there anything else?

L: No.

NvW: So that was the new thing? Cool. And how was that, was it easy or difficult to learn?

L: Difficult, difficult.

NvW: Alright. Do you think that was the most difficult thing in the course, or was there anything that was more difficult?

L: Ya.

NvW: Alright. And is there anything that you're still struggling with, that's still difficult?

L: Ya I still struggle with Fractions 7.

NvW: Is it? Ok. Is that where you're doing the cross multiplying?

L: Mm hmm.

NvW: Ok. And is that what you're going to work on today in your catch-up?

L: Ya.

NvW: Alright. Was there anything in the fractions course that you didn't like?

L: Mm hmm.

NvW: What didn't you like?

L: Cross multiples.

NvW: Why don't you like it?

L: Because I'm actually not good at them.

NvW: So you don't like it because you're not very good at it and it's difficult. Then is there anything in the fractions course that you really do like?

L: Ya.

NvW: What do you like?

L: In, now?

NvW: Ya, or just through the fractions course. What was the nice thing for you, what did you like about the fractions course?

L: Factors and multiples.

NvW: Cool. Alright. And then are you doing the fractions course in English or Zulu?

L: Zulu.

NvW: And how is that?

L: Easy.

NvW: Is it? What is your home language?

L: My home language it's Zulu.

NvW: Alright, so that's easier for you hey? And if you had the choice in the future would you choose to do it in English or Zulu?

L: English.

NvW: English? Would you rather do it in English than Zulu in the future? Why would you change?

L: I think I love English but I'm not good at English but I really love talking in English.

NvW: So the course that you're doing now, the fractions course, you know the videos had some English and some Zulu? Would you want to do the next course only in English, or still with some English and some Zulu?

L: English and some Zulu.

NvW: Ok cool. So you like having it mixed together? Cool alright. So you're still on Fractions 7 hey? Can I ask you to show me how you would do something? So we're going to go to this one, ok question 4, can you explain to me how you would do it, so we're going to pretend maybe I'm your little brother or your little sister or your friend in class who doesn't know how to do this, can you explain three and one quarter minus one and three quarters? How would we do that?

L: Can I copy this first?

NvW: Ya.

L: Ok, I was going to say 3 times 4 which gives me 12 plus 1 is 13 over 4 minus 4 times 1 which gives me 4 plus 3 is 7 over 4 cause I already have my LCM, my LCM is 4, I'm going to say 4 then I say ok 13 times 4 which is going to give me, it's 26 plus 26 is 52 then 7 times 4 which gives me 28 then make my equals sign, then I say 52 minus 28 then gives me, ok 52 minus 28 gives me 22, then this is my answer, then I simplify, it will be simplified.

NvW: Cool, thank you [name]. Then is there anything else you want to tell me about the OLICO fractions course?

L: No.

<u>Learner 5</u>

NvW: So my first question for you is was there anything in the fractions course that's new, or had you learnt everything at school already?

L: Do you mean like more things that I learn at school?

NvW: So I mean you know the fractions course that you did now?

L: Ya.

NvW: So the stuff that you learnt there, did you already know it because you had learnt it at school, or were you seeing it for the first time at OLICO?

L: Ya I learnt it at school, but not really like here at OLICO, I learnt it more than this at the school.

NvW: You learnt it more at school?

L: Ya.

NvW: Was there anything at OLICO you were seeing for the first time?

L: Ya.

NvW: What were you seeing for the first time?

L: The blocks that were in lesson like lesson 1, 2.

NvW: Alright so the blocks were new hey. Which blocks do you mean? Oh on the actual course?

L: Ya.

NvW: Alright. And then what was the most difficult thing that you learnt on the fractions course?

L: Difficult? At Fractions 8 which it's too difficult.

NvW: Oh really? Why is it so difficult?

L: Because that thing they were at the computer I didn't learn it more.

NvW: Ok. And then is there anything in the fractions course that you didn't like? Anything that wasn't nice, anything that you didn't enjoy doing?

L: I enjoy it.

NvW: All of it?

L: Yes.

NvW: Alright. What did you enjoy the most, or what did you like the most in the fractions course? What was your favourite thing in the fractions course?

L: Hmm. Do you mean that at what course did I enjoy it?

NvW: No so in fractions you know that you had fractions 1, fractions 2, was there anything about it that you really liked, like maybe you liked adding the fractions or you liked learning this one part or maybe you really liked the videos, or maybe you really liked the mixed practice.

L: I really, I like post quiz, ya.

NvW: Why do you like post quiz?

L: Because it make us learn more things.

NvW: Cool. Nice. And were you doing the course in English or Zulu?

L: English.

NvW: And why did you choose to do the course in English?

L: Because Zulu I don't know how to write it, but to speak it I know how to speak and to listen to other person who's speaking Zulu.

NvW: Oh, what's your home language?

L: Sepedi.

NvW: Ok, did you see the new course now that they're not writing any Zulu, that they're just listening?

L: Ya.

NvW: If you could do the course next time would you like to do it in English or Zulu?

L: Zulu.

NvW: So if you could choose again you would choose Zulu?

L: Yes

NvW: Why would you change your mind?

L: Um, because I was not understanding their writings. Ya.

NvW: Alright. Can I ask you now, can you show me, so what are you on at the moment, fractions?

L: 9.

NvW: 9, so you've finished fractions 7. Can you show me, when did you finish fractions 8?

L: Last week.

NvW: Alright. Can you show me how to do question 6? So it says calculate 2 over 3 times 12, but can you explain it to me like I don't know how to do it, like maybe I'm your classmate and I didn't come to OLICO the whole term, so now I don't know how to do it. Can you teach it to me like how you get taught it in the video? So will you show me how we must do this?

L: Ya. Um, 2 over 3 times 12 over 1, and then I said this times this is 24 but I don't want to do it like this because it gives me a bigger number, so three goes how many times into 12? It's 4 time. And then I cancel this one and it give me 4. And then, and then I said this times this give me 8. I said ya 8, it give me 8. Ya 8 over 3. And then ya.

NvW: And that's your answer?

L: Ya.

NvW: Cool thank you. That's great. And then is there anything else you want tell me about the fractions course, or is that everything? Anything you want to tell me? Anything that you like or didn't like or comments or suggestions? Or no comments.

L: Ya I really like lesson 5, ya.

NvW: Is it? Why do you like lesson 5 so much?

L: Because it's too easy to do it.

NvW: Ok that's good to know. Then we're done, thank you.

Learner 6

NvW: In the fractions course was there anything that you learnt that was new, that you hadn't already learnt at school?

L: It was these things, I didn't learn them at school.

NvW: You didn't learn them at school? Alright. What was the most difficult thing in the fractions course?

L: It was to subtract them.

NvW: Subtracting was the most difficult thing? Alright, is there anything that you still think is difficult?

L: No.

NvW: Is everything easy now? Alright. And then was there anything that you didn't like in the fractions course?

L: No.

NvW: Nothing. And was there anything you liked in the fractions course?

L: It was...

NvW: Nothing really? Ok. Were you doing the course in English or Zulu?

L: English.

NvW: English. And why were you doing it in English?

L: Because I don’t understand Zulu.

NvW: Alright. If you had the choice what language would you like to be learning in? If I said you could choose?

L: Sepedi.

NvW: Sepedi, alright. Sorry that we didn’t have a Sepedi one hey. Is that your home language?

L: Yes.

NvW: Alright. So if we said to you you can do fractions in English and Sepedi you would choose to do it in Sepedi, is that true?

L: English.

NvW: Would you choose to do it in English? Ok. Why would you rather do it in English?

L: Most of things I understand all of them with English.

NvW: Ok, alright. And then, have you finished fractions 8? You have hey? Can you show me on this page how you would do number 6? But can you explain it to me maybe like I’m someone else from your class who didn’t come to school for the whole term so I don’t know how to do it, can you explain it to me like that? Does that make sense? So can you show me how to do this, but can you tell me what you’re doing, so that you’re teaching me how to do this.

L: We start to say 2 over 3 times 12 over 1, and then we say 12 times 2, 12 times 2 and then it’s, is 34. And then you say 3 times 6, I don’t know this one.

NvW: Do you want to try a different one? Which one do you want to show me?

L: This one.

NvW: Alright.

L: 3 over 1, eish.

NvW: That’s 3 and 1 quarter.

L: 3, 1 over 4, minus 1 over 4, and then you say 3 times 4 plus 1 and it’s 5 over 4 then you say 1 times 4 plus 3 then you say 7 and then you say what it is 4, and we say 4 times 4 it’s 4 plus 5 it’s 5. Then 4 times 4 it’s 1, 1 plus 7 it’s 8, and then you say, and then it’s 1, it’s 2 over 4.

NvW: Mm hmm. Is that your answer? Cool. And then that's all that we need to do for now. Is there anything else you want to tell me about the fractions course?

L: No.

Learner 7

NvW: So my first question is, did you learn anything new in the fractions course? Was there anything that you hadn't learnt at school, or had you learnt all this stuff at school?

L: I didn't learn how to multiply the fraction.

NvW: So that was new?

L: Yes.

NvW: Alright, and was there any, what was the most difficult thing that you learnt in the fractions course?

L: Multiplying fraction.

NvW: Alright. And was there anything, why was that difficult?

L: Because they did not teach us at school.

NvW: Alright. Then is there anything that's still difficult now?

L: No.

NvW: Everything's easy?

L: Yes.

NvW: That's really good. Was there anything that you didn't like in the fractions course?

L: No.

NvW: Nothing, ok. And was there anything that you really did like?

L: Yes.

NvW: What did you like?

L: Adding fractions.

NvW: Ok. Why did you like adding fractions?

L: Because it is easy.

NvW: Ok, that's good. And then were you doing the course in English or Zulu?

L: English.

NvW: Ok, and how was it? Was it fun, was it difficult?

L: Fun.

NvW: Fun, alright. And why did you choose to do it in English?

L: Because some of words, some words in isiZulu I cannot understand.

NvW: Ok, what's your home language?

L:	IsiNdebele.

NvW:	Ok ya so that's a bit different hey?

L:	Yes.

NvW:	Ok, and if we told you you can learn it in English and isiNdebele, which one would you choose?

L:	English.

NvW:	English? And why would you choose English over your home language?

L:	I like English.

NvW:	Is it? Alright.

L:	Many teachers explain in English so if I'm concentrating in my home language some I won't do understand words.

NvW:	Ok that makes sense. And what are you on at the moment, are you on Fractions 7 hey?

L:	Yes.

NvW:	Alright, can I ask you to show me how, ok have a look at question 4, ok so can you show me how you would do question 4, but can you teach it to me? So pretend I wasn't at OLICO the whole term, I come back I'm so lost and I don't know how to do this, can you show me how to do this?

L:	Can I write it?

NvW:	Yes.

L:	Ok.

NvW:	Alright so can you show me what you did?

L:	Yes.

NvW:	How did you figure that out?

L:	I first said 3 times 4 plus 1 is equals to 13 and then I say over 4 minus 1 times 4 plus 3 is equals to 7 over 4 and then I said 7 minus, 13 minus 7 is equals 6 over 4 and then I simplify is equals to 1 over 2.

NvW:	Cool, you even remembered to simplify.

L:	Yes.

NvW:	Very nice [name], that's great. So this is easy for you hey?

L:	Yes.

NvW:	Alright and that's my last question. Do you have any comments or suggestions about the fractions course?

L:	No.

Learner 8

NvW:	My first question is in the fractions course was there anything that you learn for the first time at OLICO that you hadn't already learnt at school?

L: Yes.

NvW: What?

L: About fractions or other?

NvW: With fractions, ya, in the fractions course.

L: Um, there, where we were multiplying the fractions.

NvW: Multiplying fractions, so that was new?

L: Yes.

NvW: Alright, and everything else you learnt at school?

L: Ya.

NvW: Ok. And was there anything that was really difficult in the Fractions course? What was the most difficult thing?

L: The most difficult thing at the fraction course was the word problems.

NvW: Is it?

L: Ya.

NvW: Why were they so difficult?

L: There were many fractions with um ya, there are many fractions the denominators are not the same, and sometimes I don't quite get what the question is.

NvW: Ok, that makes sense. And then is there anything that is still difficult for you in the fractions course?

L: Ya.

NvW: What's still difficult?

L: Word problems.

NvW: So that's the same thing hey?

L: Ya.

NvW: Alright. Then is there anything in the fractions course that you didn't like?

L: No.

NvW: Nothing?

L: Ya.

NvW: Alright. And anything in the fractions course that you did like?

L: Ya.

NvW: What?

L: Um, equal, like to make the fractions equivalent.

NvW: Cool, so was that your favourite?

L: Ya.

NvW: And then where you doing the English or Zulu course?

L: Um, both.

NvW: The both, the mixed one. And what did you think of it?

L: It was cool.

NvW: Is it? Why was it cool?

L: Because Sir Thabiso can explain um the moodle easier than the English one.

NvW: Alright, well that's good to know. So if you had the choice in the future, what would you choose, the mixed one or the English one?

L: The mixed one.

NvW: That's nice. Then I just want to ask you to explain something to me. So you said you are on Fractions, you finished hey, you're on word problems now? Alright. So can I ask you if you look at question 6 can you explain it to me? So you can show me how to do it, and then pretend that I haven't been at OLICO the whole term and I don't know how to do this, can you explain how to do this?

L: Ok it says 2 of thirds multiply by 12. So the way I do it I say 2 thirds multiply by 12 over 1. Then I multiply 2 with 12 which I get 24. Then I multiply 3 and 1 equals to 3. Then this is an improper fraction, so we have to say 3 gets how many times into 24? 8 times. Then your answer is 8.

NvW: Very nice, very, very nice. Cool, and then I think that is everything. Do you have anything else you'd like to tell me about the fractions course? Do you have any comments or suggestions or questions?

L: Um, the person who did the moodle is the best one.

NvW: That did the? The moodle?

L: The people, the person who created this moodle is the best.

NvW: Oh really? Awesome, that's so nice to know. Thank you very much, and we're done.

Appendix G

Learner interview questions

1. What did you learn in the fractions course?

2. What was the most difficult thing you learnt?

3. What did you like about the fractions course?

4. What didn't you like about the fractions course?

5. Can you explain how you would do this problem?

Fra3: Equivalent fractions

Use the fraction wall to find all fractions that are equivalent to 4/12

Fra4: Improper fractions to mixed numbers

Write 10/3 as a mixed number

Fra5: Converting mixed numbers to improper fractions

Write 2 ¾ as an improper fraction

Fra6: Adding and subtracting numbers with the same denominator

Calculate 3 ¼ - 1 ¾

Fra7: Adding fractions with different denominators

Calculate 3 5/6 – 1 2/15

Fra8: Multiplying fractions

Calculate 2/3 x 12