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Crossing the frontier from oral to written translanguaging for epistemic access in natural science

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Background: South Africa's *Language-in-Education Policy* (LiEP) provides for bi/multilingual education, but schools are only supported to choose monolingual English language policies from Grade 4 and ignore the learners' home language or languages as resources for learning. Many teachers translanguage orally, using the learners' home language and English to make learning more meaningful but seldom extend this to written translanguaging.

Objectives: Research was conducted to document the process and effects of a teacher development project, translanguaging-for-learning (L4L) which supported teachers in developing translanguaging pedagogies to improve learner access to the curriculum and to develop academic bi-literacy.

Method: This article focuses on the development of one senior phase (Grades 7–9) natural science teacher who participated in the L4L project. Data were collected following an ethnographic approach in workshops and classrooms through observation, interviews, photos, videos, and learners' workbooks.

Results: The research illustrates how with workshop engagement, mentoring support and the provision of multilingual dictionaries, a teacher's bi/multilingual languaging skills were legitimised and mobilised to engage learners in knowledge construction, both orally and in writing. Classroom interaction shifted from being teacher-led to being more learner-centred and bilingual, providing opportunities for biliteracy, and identity affirmation.

Conclusion: The findings illustrate improved learning opportunities through planned, systematic translanguaging pedagogies.

Contribution: The research suggests a model for bi/multilingual education and teacher development that recognises African languages as important resources for learning to further linguistic equity, access, and social justice.

Keywords: decoloniality; pedagogical translanguaging; teacher education; bridging discourses; bi/multilingual education.

Introduction

The sub-standard performance of most South African learners in international assessments of mathematics and science (TIMSS) and reading literacy (PIRLS) (2021) is frequently framed in deficit terms – the failure of teachers to teach properly and the failure of learners to learn (Mayaba, Otterup & Webb 2013). What such commentary does not acknowledge, is the systemic failure of the education system to provide most learners with adequate opportunities to learn (McDonnell 1995) by ignoring the most valuable learning resource learners bring to school, namely their home language or languages (McKinney 2017).

Current school language policies with an early switch to English as the Language of Learning, Teaching and Assessment (LoLTA) in Grade 4, block epistemic access (Kerfoot & Bello-Nonjengele 2023; Makalela 2015a) to the curriculum for most African language speaking learners. This problem has been recognised and well documented in research for at least 30 years: see, for example, Macdonald's research (1990:141), where she describes the effect of the sudden switch to English medium instruction, where learners have little access to English outside the classroom:

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> The global effect … is loss of meaning. The children are likely to be alienated by what they must learn, and only dimly perceive the implications and linkages between the concepts they are presented with. (p. 141)

These policies are largely driven by anglonormative language ideologies that are rooted in the enduring legacy of coloniality (McKinney 2017). Currently, teachers are caught between teaching in English or providing access to curriculum content through the learners' most familiar language. Many teachers switch to the learners' home language in order to facilitate understanding but they do so covertly and with a sense of guilt (Probyn 2009; Setati et al. 2002). As a result, the potential for fully developing translanguaging pedagogies that are planned, systematic and include orality and writing, have not been realised. It is these challenges that the Languaging-for-Learning (L4L) project set out to address.

The L4L was an intervention project and practices were conceptualised around the idea of a 'cycle of change', aimed at ensuring epistemic access and epistemic justice (Kerfoot & Bello-Nonjengele 2022; Makalela 2015a). Drawing on analysis of the photographs and thematic analysis of the interview data, we analyse the cycle of an emerging and evolving intervention on the application of multilingual teaching and learning strategies in a high school science classroom. We foreground the use and analysis of language, literacy, and translanguaging practices in constructing science and scientific practices. Since research on translanguaging practices has primarily been aimed at the analysis of oral practices (De Morais & Hübner 2023), our aim here is to examine how oral practices have developed into writing (what we call crossing text frontiers) through collaboration between the researchers and teachers, and the teacher and learners. In their South Africa-Sweden Links project, Webb and Mayaba (2010) explored the development of scientific literacy in South African classrooms and revealed that, not only do learners find it difficult to read, write, and argue when learning through an additional language, but that they are generally exposed to very little writing in the science classroom. In another study, Mayaba et al. (2013) show that teachers in both South Africa and Sweden were not aware that oral discourse carries features of written text types. Thus, our inclusion of written practices and our analysis of the teachers' movement from oral to written practices stems from the understanding that speech can be a rehearsal for writing and from the fact that '[*m*]etacognitive engagement in writing is crucial to effectively developing, applying, and transferring [*learning*] strategies' (De Morais & Hübner 2023:7).

Conceptual framework: Conceptualising socio-cultural, translanguaging, and decolonial science teaching

The conceptual framework that guided the L4L project and the research described in this article, was drawn from the inter-linked fields briefly outlined, namely socio-cultural views of language and learning, languaging for learning in multilingual contexts, and translanguaging theory (TL). We also drew on decolonial theory to surface epistemic injustice (Fricker 2007) in education. These theories allowed us to address coloniality around language and literacy by disrupting anglonormativity and monolingualism. Drawing on these theories, we address the research question: What bi/multiliteracy pedagogical practices, in the cycle of change implemented by the L4L project, were used to support both the teacher and the learner oral and written language development in Grades 8 and 9 Science?

Socio-cultural approaches to language and learning

The broad conceptual framework for the L4L project was that of socio-cultural approaches originating in the work of Lev Vygotsky (1978) that place interaction through language at the centre of knowledge construction – for both classroom teaching and learning, and for teachers engaged in professional development (eds. Calderhead & Gates 2003). Since language and literacy was an important focus, the L4L project drew on Gee's (1992, 2013) conceptualisation of discourse. Gee (1992) distinguishes between 'Discourse' (capital 'D') as ways of speaking, being, interacting, and living in the world, and 'discourse' (lowercase 'd') as language in use. We also drew on Gee (2013) and his related concepts of primary and secondary Discourses. Gee (2013:13) argues that our primary Discourse consists of the languages, values, and everyday ways of being we learn as a child. Our secondary Discourses are the specialised languages and roles found in different domains in which we participate, for example at school, in science, and mathematics. These concepts were used to help the high school teachers understand that, when the language of the home and school are similar, children are advantaged and can build on this alignment. But when the secondary Discourse of the school does not make provision for the primary Discourse of the learners, there is a disjunct and the learners are placed at a disadvantage. We also drew on Barnes (1992) and his concepts of exploratory and presentational talk and writing to explain to the teachers the importance of using the learners' full linguistic repertoires. Presentational talk offers a 'display' of knowledge, whereas exploratory talk and writing are for thinking and is characterised by hesitancy and incompleteness (Barnes 1992). Underpinning the focus on exploratory talk, dialogue, and writing in the classroom is the understanding that learners are social beings and therefore learn through social interaction (Vygotsky 1978). Central to social interaction is authentic dialogue, collaboration, and reflection – not mere banking of information (Freire, cited in Gee 1992; Gibbons 2009). Gibbons (2009) argues that:

> [*A*]s learners engage in conversations either with peers or with more expert users, meanings are constantly being negotiated through clarification questions, confirmations of meaning, and adjustments to what has been said. (p. 134)

This dialogue and exploration thus allow for scaffolding and mediation by the teacher or more knowledgeable peers.

The focus on language and literacy in the L4L project was also contextualised according to subject content. For example, discussions with the science teachers in the workshops involved making the teachers aware of the differences between everyday language and the language of science, and its hierarchical knowledge structure (Lemke 2004; Mortimer & Scott 2003). Part of learning science involves learning how to talk, read, and write scientific language (Tyler 2023); thus mastering the secondary Discourse of science (Gee 2013). In the workshops, the researchers discussed the features of science language with the teachers such as precision of meaning; use of technical terms; everyday words that are ascribed specialised scientific meanings, for example power, force, current; the use of the passive voice; and the use of particular text types such as information reports, explanations, and procedures (Lemke 2004; Mortimer & Scott 2003).

The researchers in the workshops highlighted that the learners needed to bridge several gaps: between everyday understandings and scientific understandings; between everyday language and scientific language; and in many South African classrooms, between their home languages and the language of learning and teaching, namely English. In Gibbons (2006) work on 'bridging discourses' in science lessons she illustrates how teachers can manage whole-class talk to help learners bridge these conceptual and language gaps, across the exploratory-presentational language continuum. The challenge for all learners in science classrooms is to master the particular register of science. In many South African classrooms, this challenge is amplified by the challenges of learning through the medium of an unfamiliar colonial language, namely English (McKinney 2017).

Translanguaging-for-learning in multilingual classrooms

Another lens used by the researchers is that of learning in bi/multiliteracy classrooms and there is an established body of research in South Africa documenting the covert code-switching practices of teachers and learners in multilingual classrooms where the official policy is that of English monolingualism (eds. Adler & Reed 2002; Charamba 2023; Makalela 2015a; Mbude 2019; Msimanga & Lelliott 2014; Nomlomo 2010; Probyn 2009; Setati et al. 2002, 2009; Tyler 2023). Such practices have remained stigmatised by education authorities rather than being recognised as valid pedagogic practices. While there are long-standing examples of sanctioned and supported 'dual medium' bilingual education in South Africa (Malherbe 1943), this is only for English-Afrikaans bilinguals. The L4L project drew on these examples as well as more recent ideas on multilingualism in education, including the notion of translanguaging as a planned strategic multilingual pedagogy (Cenoz & Gorter 2017; Probyn 2015, 2019) that enables epistemic access and the development of academic bi/multiliteracy (Kerfoot & Bello-Nonjengele 2022; Makalela 2015a). García and Li Wei (2014) define translanguaging as an:

> [*A*]pproach to the use of language, bilingualism and bilingual education that considers the language practices of bilinguals not as two autonomous language systems (…), but as one linguistic repertoire with features that have been societally constructed as belonging to two languages. (p. 1)

Makalela's concept (2015b:15) of ubuntu translanguaging also helps to make the case 'that fuzziness and blurring of boundaries between languages in the translanguaging classes are necessary and relevant … to enhance epistemic access for speakers in complex multilingual spaces'.

The cognitive advantages of flexible bi/multilingual learning have been supported by research (Bialystok 1991 & Cummins 1999 cited in Soares De Sousa, Greenop & Fry 2010). Cummins (2008) proposed the notion of 'teaching for transfer', namely that concepts and skills learned in one language can transfer across languages. The translation of concepts from one language to another not only opens epistemic access but also enables 'a deeper and fuller understanding of subject matter' (Baker 2001:281). Despite this evidence, anglonormative ideologies rooted in coloniality have obstructed any sincere consideration of translanguaging, translation, and African languages as languages of academic learning (Ndhlovu & Makalela 2021).

Decoloniality and language-in-education ideologies

Our research takes a decolonial approach and we draw on the work of Mignolo (2007), Ngugi wa Thiong'o (1986) and Quijano (2007) to challenge the coloniality of English monolingualism and as a starting point for our cycle of change. Mignolo (2007:459) describes decoloniality as a 'means of working toward a vision of human life that is not dependent upon or structured by the forced imposition of one ideal of society over those that differ' and this includes the imposition of one language over and above other languages. Mignolo (2007:463) argues that decoloniality involves a constant double movement between unveiling epistemic violence or coloniality and 'affirming the modes and principles of knowledge that have been denied' by giving voice to that which has been silenced and erased. The first movement of decoloniality involves recognising what Quijano (2007) calls modernity/coloniality the understanding and knowledge that our modern world is constituted by a violent colonial past that continues in the present as coloniality. For Quijano (2007), there is no modernity without colonialism and coloniality. It is a mutually constitutive and continuing process; it is thus always modernity/coloniality. The second movement is affirming knowledges and modes which have been denied, erased, or ignored by modernity/coloniality. For the researchers in the L4L project, the decolonial double movement (Mignolo 2007) involved unveiling colonial language ideologies, including the myths around language such as anglonormativity (McKinney 2017) in the workshops. Most of the teachers in the project had been educated at universities where English was the language of instruction and had been socialised into believing in the

dominance of English and in implementing English as the LoLTA in schools even though English is not the primary language of the teachers and learners. Another aspect of epistemic violence that was unveiled, was disinvestment and disbelief in the idea that African languages were viable languages for knowledge production, especially in subjects such as science, technology, and mathematics. The first aspect of Mignolo's 'double movement of decoloniality' and unveiling epistemic violence thus involved what Ngugi wa Thiong'o (1986) called 'decolonizing the mind'. The second aspect of Mignolo's 'double movement of decoloniality' (2007:463) involved 'giving voice to that which has been silenced and erased'. We aim to do this through the analysis of the 'take-up' of the intervention by the teacher and the learners in the 'cycle of change' (Reed, Davis and Nyabanyaba 2002). We draw the idea of 'take-up' from the research of Adler and Reed (eds. 2002), who in their work on teacher development, define 'take-up' as 'what is learned and how it is learned' in teacher development programmes. In our discussion and description of the 'cycle of change' that follows, we reveal how an African language speaking high school science teacher, with the support of the researchers or mentors of the L4L project, reclaimed African languages as languages of science whilst also building the learners' understanding of science knowledge in English.

Research methods and design

This research is a qualitative case study of the bi/multiliteracy strategies taken up by both the teacher and her learners to support the learning of science in one science classroom. Drawing on Bogdan and Biklen (1997), qualitative case study research facilitates the collection of data which includes detailed descriptions of practices, people, places, social interaction, and conversations. To obtain a detailed or 'rich description' (Bogden & Biklen 1997), we used ethnographic tools such as document collection, audio and video recordings of classrooms and workshops, participant observation, photographs and fieldnotes as well as interviews, which produced multiple sources of data. Taylor (2013) argues that, although multiple data sources are considered problematic from a positivist view of research, in qualitative research, multiple data sources allow the researchers to examine and understand the problem across many levels (Taylor 2013:811). The research was participatory and collaborative as we cooperated with the teacher in the L4L workshops and with the teacher and her learners in her classroom. We were also two researchers (Soraya Abdulatief and Xolisa Guzula) who collaborated and used our experience to analyse and interpret the data. We describe the cycle of change of the teacher development process and reflect on team-teaching and the demonstration of processes and praxis in the teacher development intervention with our selected Grades 8 and 9 teacher. We show that participatory research and collaborative linguistic ethnographic methods are useful methodologies for doing decolonial work.

Setting

The research setting was a low resourced but high functioning high school in Khayelitsha township in Cape Town, located in a historically under-served community with some brick houses, but where most people live in 'informal' homes or structures. We describe a 'high functioning' school as one that follows set timetables with very little absenteeism, where staff are conscientious, arrive on time, prepared and the learners are focused, and do their work with low levels of serious disruption and criminality. It is also a school that performs consistently well in the final national matriculation examinations, and there is collegiality between staff members and between staff and students. The school was also overcrowded with about 45–50 learners in a class and some classrooms had defective desks, cupboards, or broken windows. While there were textbooks, a whiteboard and chalkboard in the classrooms, there was no access to digital media. A few learners had access to mobile phones and data. In classes where there was a whiteboard, it required additional upkeep and resources in the form of special markers and whiteboard cleaners which were largely unavailable. In most classrooms, the chalkboard was thus used for teaching most frequently.

Research participants

The research participants are Mrs KM, the science teacher, and her 45 learners, whom the researchers followed from 2022, when she taught a Grade 8 natural science class, to 2023, when the same learners progressed to Grade 9. The learners were between 13 and 14 years old in 2022 and between 14 and 15 in 2023.

The teacher, Mrs KM, has Sesotho, isiXhosa, Afrikaans, and English in her language repertoire, but is biliterate in Sesotho and English. Like most Sesotho speakers from the Eastern Cape, Mrs KM has oral communicative competence in isiXhosa. Her learners are isiXhosa – emergent English bilinguals with a few learners developing bilingual and biliterate competence in both languages. Although Mrs KM has this rich linguistic repertoire, in the early stages of the research, she admitted to having a monolingual and anglonormative bias to English, as she was against using isiXhosa and only taught in English.

Intervention: The Languaging-for-learning (L4L) project

To challenge the epistemic injustice described in the introduction, a team of South African teacher educators from four universities developed the L4L project, a pilot intervention, funded by Zenex Foundation over 2 years (2022–2023). The intervention was aimed at Grades 8 and 9 English First Additional Language (EFAL), natural science, English and mathematics teachers in 10 schools in Cape Town where most learners and teachers identified isiXhosa as their home language and English was the LoLTA. The aims of the L4L project were twofold: firstly, to equip teachers to provide learners with the necessary literacy

skills in both English and their home language or languages; and secondly, to engage learners' full linguistic repertoires, including their home language or languages and English to access and engage with curriculum content.

The L4L project was structured around two core activities: firstly, a series of foundational and practice-based workshops; and secondly, classroom-based support and mentoring provided by the L4L researchers or mentors. The foundational workshops were held over six consecutive weeks in Term 2 of 2022. Next, two to three practice-based workshops were held in Term 3 in 2022 and in Terms 1, 2 and 3 in 2023. The second core activity of the L4L project was classroom-based support and mentoring provided by researchers of the project in the third term of 2022 and in Terms 1, 2 and 3 in 2023, with five to six school visits per term. The classroom-based support-built links between the workshops and classroom practice, providing teachers with encouragement and the confidence to try out new ideas as well as opportunities to reflect on their teaching.

Data collection and sources for this article

Between 2022 and 2023, Abdulatief and Guzula visited the school and Mrs KM's Grades 8 and 9 science classes once a week and collected data through classroom observations, photographs of the writing done on the chalkboard, on posters, and in the learners' books. We also collected field notes and audio and video recordings of parts of the lessons, interviews, and informal conversations with the teacher. In this article, we draw on photographs that illustrate stages in the teacher or classroom support from initial early practices, the recorded lesson observations on the topic of compounds and chemical reactions (Figure 9), and Mrs KM's reflections on her changing language ideologies, pedagogical practice and growing independence in applying the learning from the L4L intervention project (Figure 11).

Ethical considerations

Ethics was carefully considered and informed consent was received from the principal, teachers, learners, and their parents for the researchers to work in the classrooms, to support teachers and document the development processes for research purposes. Schools, teachers, learners, and parents were assured of their confidentiality and informed that their participation is voluntary and that they could opt out at any point in the process if they wished.

Results and discussion: Analysing an emerging and evolving intervention

Next we describe and analyse the cycle of change we were engaged in with the teachers, and then follow it up with the analysis of the 'take-up' of the intervention by the teacher and the learners.

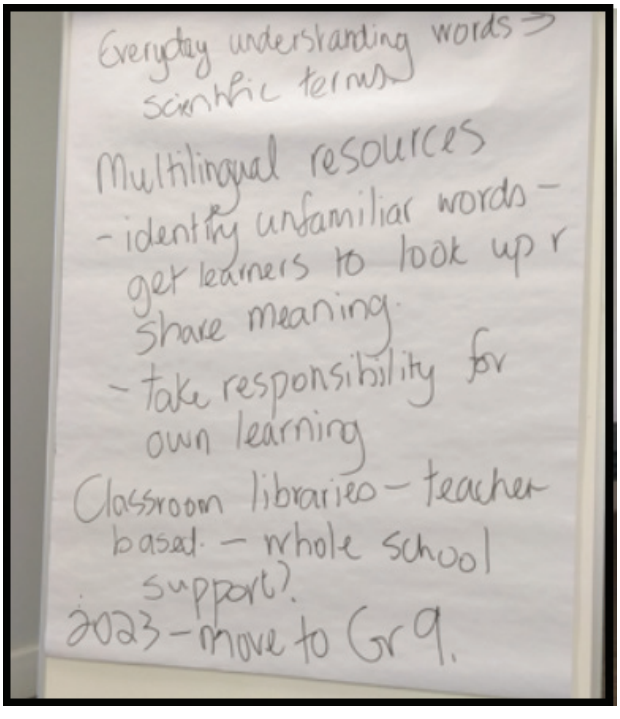
'Cycle of change' step 1: The teacher training workshops

To initiate the 'cycle of change', we provided support for teachers through workshops which covered the following:

- Early perceptions and fears of using isiXhosa in the classroom due to the English LoLTA policy in schools.
- Laying the foundation around translanguaging and language ideology.
- Legitimating the teachers' use of African languages.
- Working with the Annual Teaching Plans (ATPs) and the Curriculum Assessment Policies (CAPS).
- Using bi/multiliteracy strategies in successive workshops.
- Translating terminology, creating glossaries, creating multilingual posters.

The workshops were initially run for the whole group and in later practice-based workshops, teachers were divided into subject specific groups, namely English, science, and mathematics. Teachers were taught to co-create resources with peers based on units of learning that were in the curriculum. Figure 1 shows a list of teacher ideas from an L4L workshop. Figure 2 shows science teachers in a L4L workshop discussing how to create a bilingual poster for teaching the reproductive system. Teachers drew on natural science textbooks in English and in isiXhosa, bilingual dictionaries, and their own multilingual resources.

In the workshops, teachers learned that the challenges with language and meaning making they experienced in their own classrooms are common and that, with support, teachers could participate and be involved in problem solving. This



Source: Photo by Robyn Tyler

FIGURE 1: List of teacher ideas from a Languaging-for-Learning (L4L) workshop in 2022.

collaborative work allowed them to explore their collective creativity and innovation and improve their pedagogy. As content subject teachers, they could also standardise terminologies for concepts they taught. The teachers were provided with resources such as bi/multiliteracy dictionaries to support learning. Figure 3 shows multilingual maths and science dictionaries that were provided to teachers in one of the first workshops, or shared with them in later workshops and classrooms.

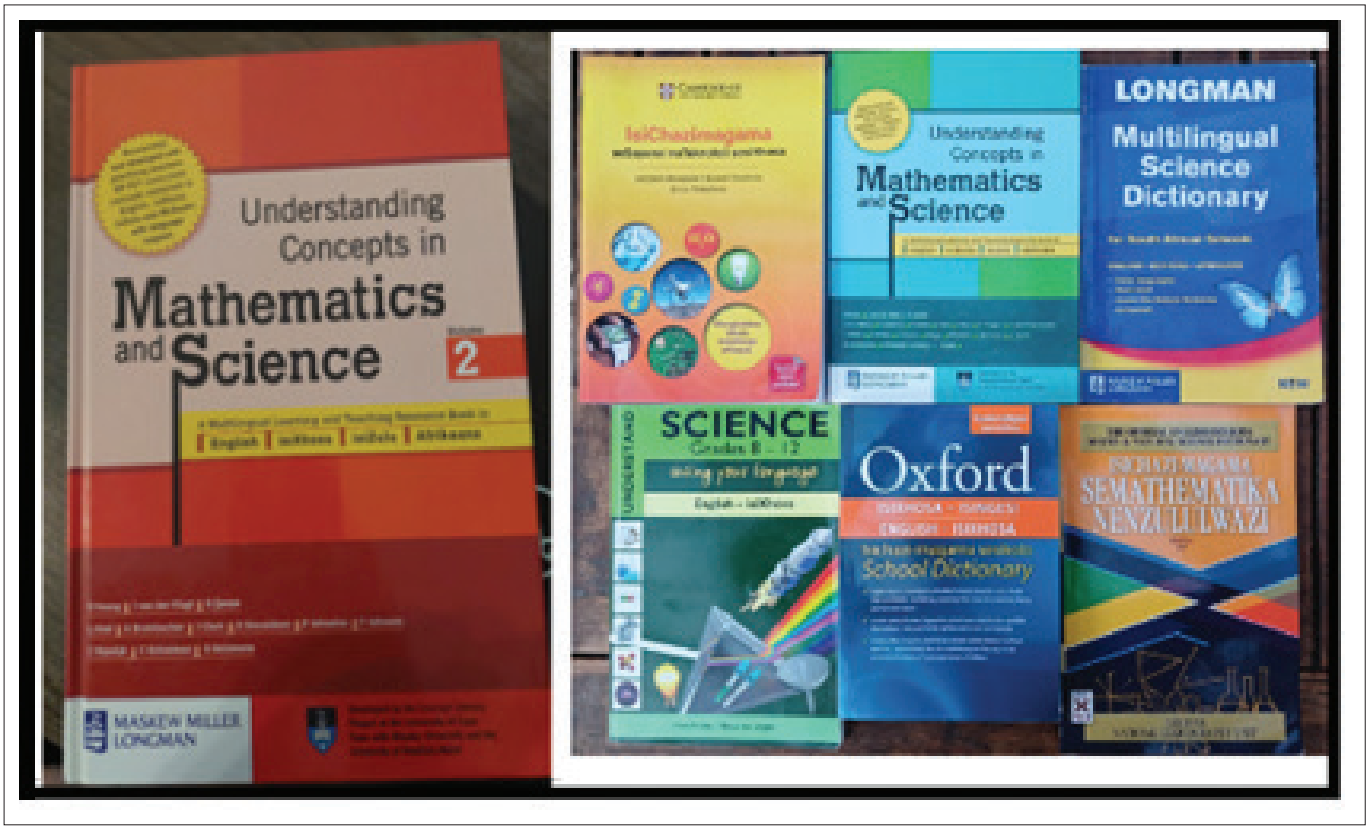
Wababa (2024) argues that dictionaries have received little attention in the CAPS curriculum, although many learners struggle to learn content subjects through the medium of English. Bi/multiliteracy dictionaries are pedagogical resources that can alleviate the conceptual and linguistic challenges learners face when used in addition to learners home languages in learning. Dictionaries remain important and have both communicative and cognitive functions (Wababa 2024).

Source: Photo by Robyn Tyler

FIGURE 2: Science teachers designing bilingual posters during a Languaging-for-Learning (L4L) workshop.

Facilitating the use of multilingual dictionaries at the workshops helped to dispel myths about the inability of African languages to function as languages of science and mathematics. Without standardised scientific words in African languages, some teachers often coined terms in isolation and this is problematic, as science requires precise meanings and understanding. Other teachers used English only as they were reluctant to coin words which may be considered inaccurate and not scientific. The multilingual dictionaries were supportive learning and reference tools for teachers trained to teach subject content in English, and who were reluctant to implement bi/multiliteracy strategies, due to a lack of resources for supporting their teaching in African languages.

In the workshops, with the use of multilingual dictionaries (Figure 3) and support, teachers were repositioned as knowledgeable and formed a group of pioneers in the construction of science terms in their languages. Teachers also engaged in critical evaluation of the terms in the dictionaries, and learned that they could coin new terms in African languages if they found terms in the dictionaries to be ambiguous. Swanepoel (2008, cited in Wababa 2024) claims that dictionary criticism is the evaluation, negative



Source: Billingual and multilingual dictionaries - Languaging-for-Learning (L4L) workshop, photo by Xolisa Guzula

FIGURE 3: Multilingual mathematics and science dictionaries.

or positive, of the design features of dictionaries based on one or more lexicographically relevant evaluation criteria. Engaging in dictionary criticism enabled teachers to appreciate having different dictionaries from different publishers. Teachers could reflect on the dictionaries that provided better definitions and examples for their learners. They also learned that borrowing terms from English and transliterating them into isiXhosa is a normal process of any language and terminology development, especially where there are ambiguities. They learned that having synonyms where there are existing or 'original' terms and borrowed terms is a good strategy for dealing with linguistic diversity, for example using the terms *ioksijini* or *umongo-moya* in isiXhosa for oxygen (see Table 1).

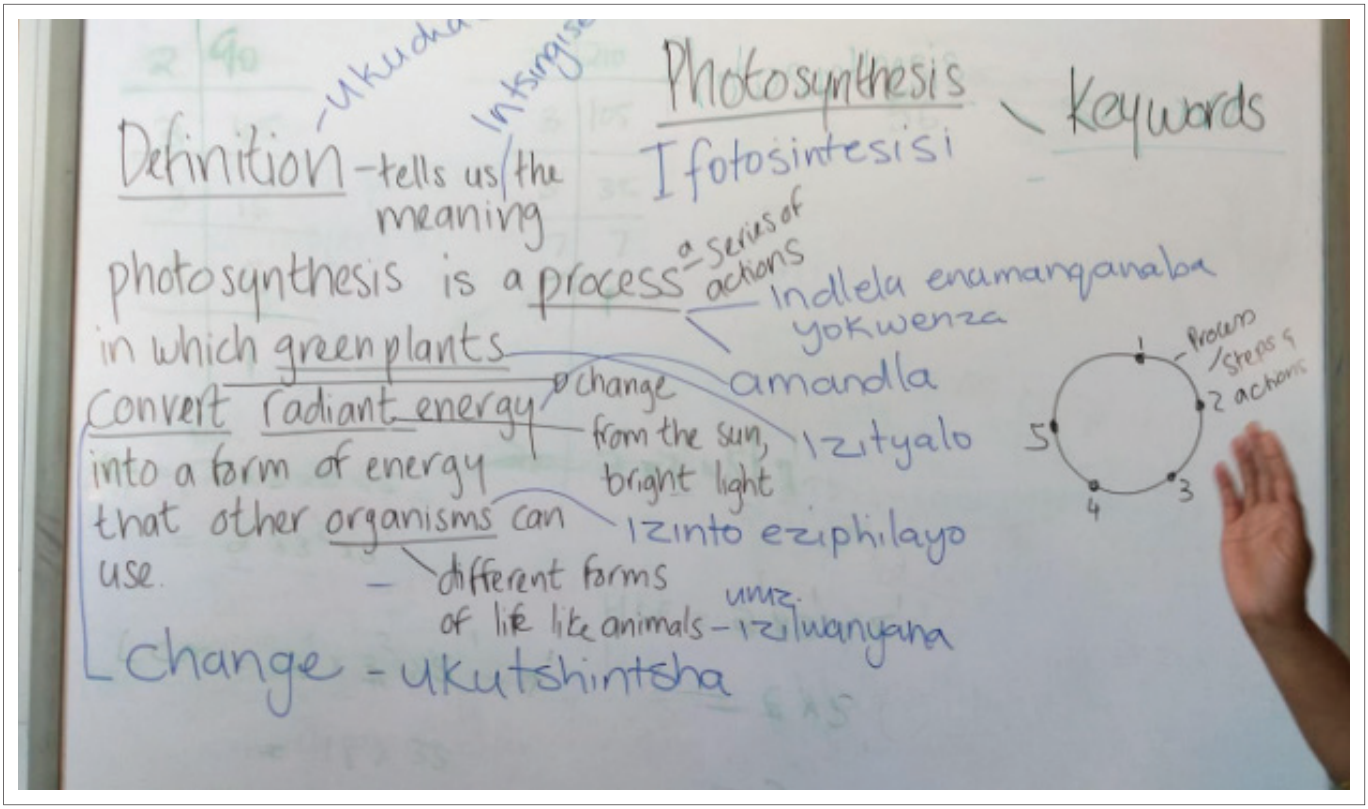
Having these varieties is also a scaffolding strategy for introducing original but unknown or newly coined terms to learners. The general understanding was that we need to value the appropriation of terms into isiXhosa for learning purposes and give learners access to precise scientific and mathematical language that would assist them during exams, as assessments are still taken in English. But more than relying on dictionaries, teachers were taught to create terminology posters with the assistance of dictionaries as the dictionaries are still a rare resource and are not readily available.

TABLE 1: A depiction of how a collaborative teacher-researcher-mentor translanguaging strategy introduce linguistic diversity in science.

English	isiXhosa original/coined term/ explanation	isiXhosa loan term
Oxygen	Umongo-moya	ioksijini
Metal	intsimbi	imetal
Photosynthesis	Indlela izityalo ezizenzela ngayo ukutya kwazo	ifotosintesisi
Compound	imbumba	ikhompawundi
Chlorophyll	Intlaza	iklorofili

'Cycle of change' step 2: Classroom support – translation and glossaries

The teacher workshops were followed by classroom support intervention, which worked in a cycle with further follow-up workshops. Researchers visited the teachers in their classrooms to support their use of the resources and the implementation of practices taught in the workshops. While present in Mrs KM's classroom, Abdulatief and Guzula observed the classroom interaction to better understand the complexity of teaching subject specific content through an unsupported additional language. We also provided support before and during lessons by sometimes team-teaching with the teacher, by assisting the teacher with preparing parts of the lesson through creating bilingual resources with terminologies and concepts, or by demonstrating how to work bilingually in both oral and written discourse. Crossing the frontiers from oral to written bilingual discourse was done deliberately, because teachers are known to translanguage orally but seldom in writing on the board or by allowing their learners to write bilingually in their notebooks and in assessment. Figure 4 shows an example of our bilingual team-teaching work and translanguaging in writing on the board.



Source: L4L classroom mentorship, photo by Soraya Abdulatief

FIGURE 4: Demonstration of bilingual work on the board by mentoring researchers in a Grade 8 classroom.

Figure 4 shows our very first demonstration lesson for creating an English-isiXhosa glossary for the topic on 'Photosynthesis' in Mrs KM's Grade 8 science class. Abdulatief wrote the key words from the textbook in English and English everyday language explanations on the whiteboard in black ink and Guzula wrote the translations in isiXhosa and everyday explanations coming from the class discussion with Abdulatief, Mrs KM and the learners in blue ink. Abdulatief in black ink, wrote the meaning of the word 'definition' as a word that 'tells us the meaning'; 'process' as 'a series of actions' and 'steps and actions'; 'convert' as 'change'; 'organisms' as 'different forms of life, like animals'; and 'radiant energy' as 'bright light, from the sun'. Tyler (2023) describes this process as trans-registering between scientific and everyday registers and shows the value of this for meaning making by learners. After writing the everyday meanings of these scientific words, Guzula, in discussion with Mrs KM and the learners, wrote the equivalent terms or meanings of the English words in isiXhosa in blue ink. The word 'photosynthesis' became 'ifotosintesisi'; 'process' became 'indlela yokwenza'; 'energy' became 'amandla'; 'green plants' became 'izityalo'; 'organisms' became 'izinto eziphilayo'; and finally, 'convert or change' became 'ukutshintsha'.

Gibbons (2009:141) refers to the oral discussion that led to the written work on the board as described above as 'bridging the discourses' in the teaching of emergent bilingual learners. Thus, drawing on the learners' full linguistic repertoires (Busch 2012) or heteroglossic practices (different languages, varieties and registers) (Bakhtin 1981) to give them the kind of oral language that is closer to written language and then writing it down, helped to bridge the everyday, primary, and the secondary Discourses in the science lesson (Gee 2013). As we were going through this discussion, the learners were asked to take notes in their notebooks and for the first time, they started crossing the oral frontier by writing bilingually. In researching the meanings of words, we used the one *Longman Science Maths dictionary* that the teacher had at her disposal, which she received at one of the workshops. When we were not satisfied with terms or meanings from the dictionary or when some of the words had not been recorded, we used our cellular phones to access the Internet. When the Internet gave explanations that were not satisfactory, we engaged in discussion and tapped into our own knowledge and understanding. As the learners were part of the discussion, they observed us working with dictionaries and heard our conversations about how one dictionary was insufficient or how we could not find original terms in isiXhosa for words like photosynthesis, and that we had to borrow them from English. They also learned not to accept the first definition they come across, but to confirm it using other additional dictionaries or discussion with their peers and the teacher. Thus, they too began to learn to offer dictionary criticism (Wababa 2024) and began to write agreed definitions.

This process was important, because it made learning exploratory and dialogic, as opposed to transmission and regurgitation of facts only through presentational talk (Barnes 1992). It also expanded children's linguistic repertoires (Busch 2012; Marshall, McClain & McBride 2023) while supporting their understanding of the scientific register - a secondary Discourse. It gave them opportunities to work collaboratively in small groups, to share resources and to look after them.

Learners creating bilingual glossaries

As we explained the terminologies on the board, trans-registering between scientific register and everyday language (Tyler 2023), learners also began to learn about how to use dictionaries as pedagogical tools for learning (Wababa 2024). At the same time, Mrs KM produced her own innovative approaches to encourage her learners to use dictionaries as well as to create their own bilingual glossaries (Table 2). Her process included creating systematic columns more suited to scientific ordering than the free-form mind map created by Abdulatief and Guzula in Figure 4. Mrs KM's strategy included learners underlining unknown words from their science textbook and then searching for meanings in multilingual subject specific dictionaries donated by the L4L project and writing the concept definitions into their notebooks. Figure 5 shows learners working with multiple texts at the same time: reading from their textbooks, finding meaning from the dictionaries or cellular phones and writing the equivalent terms in their own personal glossary.

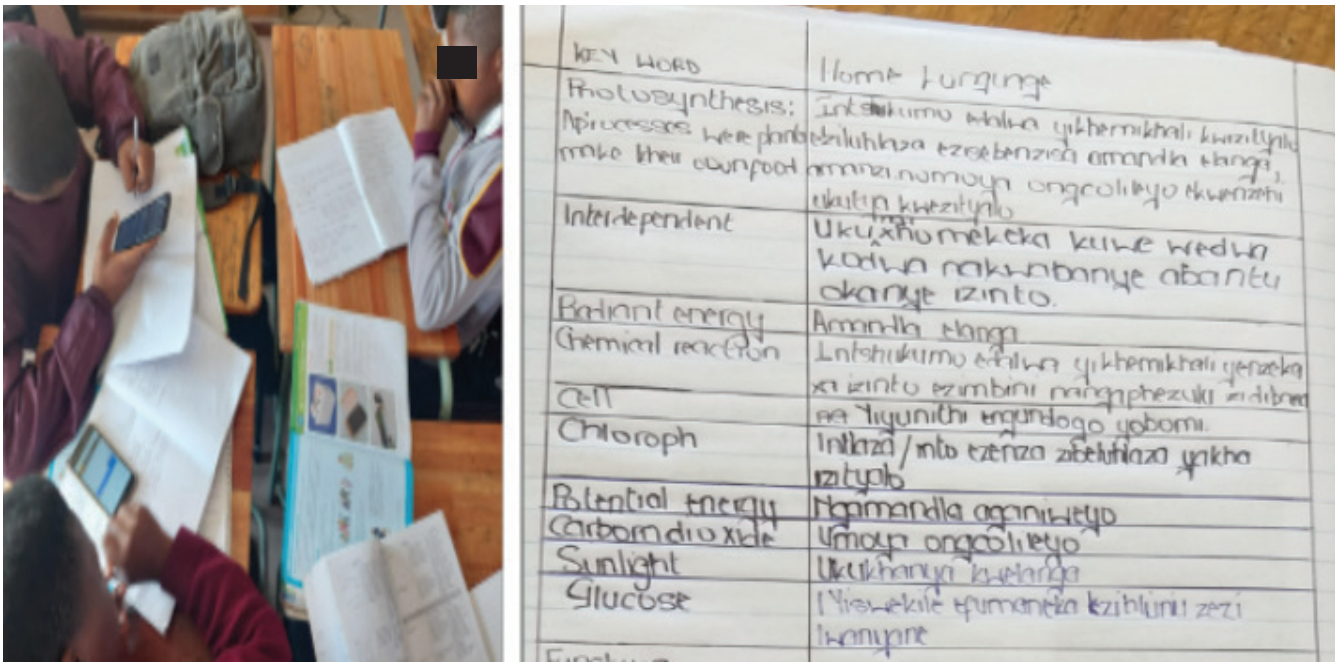
In the process, learners learned how to use translation and bilingual dictionaries – printed and online – to create their own isiXhosa-English glossaries. Given that dictionaries are scarce in schools, getting learners to engage in this glossary making activity is a necessity. When there were not enough dictionaries, the few learners who had mobile phones were encouraged to use their phones, as can be seen in Figure 5. Figure 6a, shows a learner using a cellular phone to look up a word and write down the isiXhosa explanation into their glossary.

'Cycle of change' Step 3: Analysis of the 'take-up' of the intervention by teachers:

Mrs KM changed her pedagogy from traditional Initiation-Response-Feedback/Evaluation (IRF/E) classroom interaction (Gibbons 2009) to repositioning the learners as bilingual researchers. Mrs KM attended the training workshops regularly and was eager to implement the bilingual

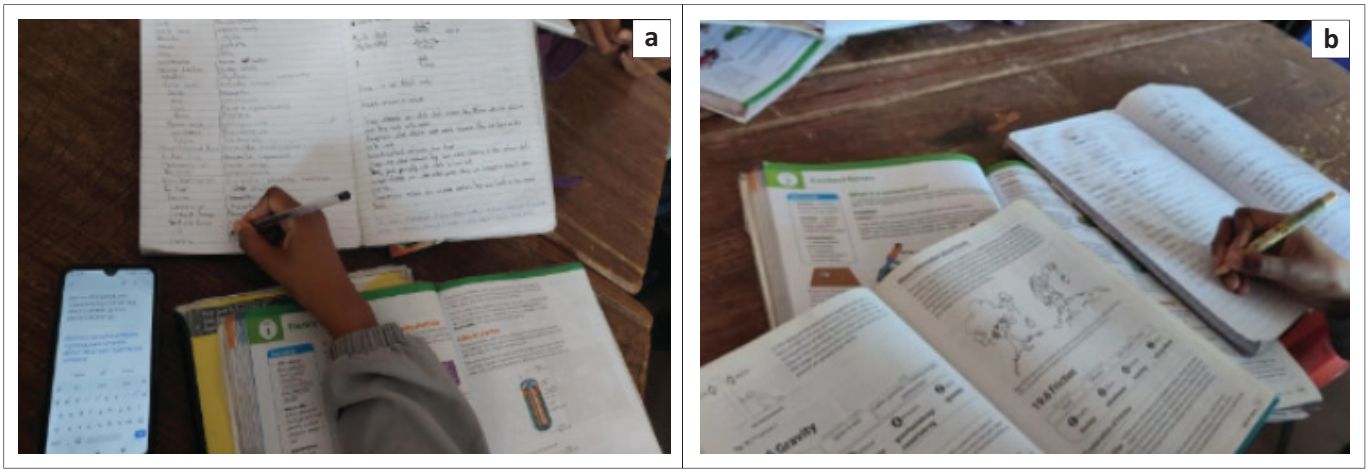
TABLE 2: A representation of the outcome of an innovative approach to encourage learners to utilise dictionaries and develop their own bilingual glossaries.

Science language in English	Everyday language in English	IsiXhosa equivalents or translation
Photosynthesis	Not given.	ioksijini
Definition	Tells us the meaning.	imetal
Process	A series of actions steps and actions.	ifotosintesisi
Radiant Energy	Bright light from the sun.	ikhompawund
Convert	Change.	ukutshintsha
Organisms	Different forms of life-like animals.	izinto eziphilayo
Energy	-	Amandla
Greenplants	-	Izityalo



Source: L4L classroom observation, photo by Soraya Abdulatief

FIGURE 5: Learners creating glossaries relating to the topic of photosynthesis.



Source: L4L Classroom observation, photo by Soraya Abdulatief

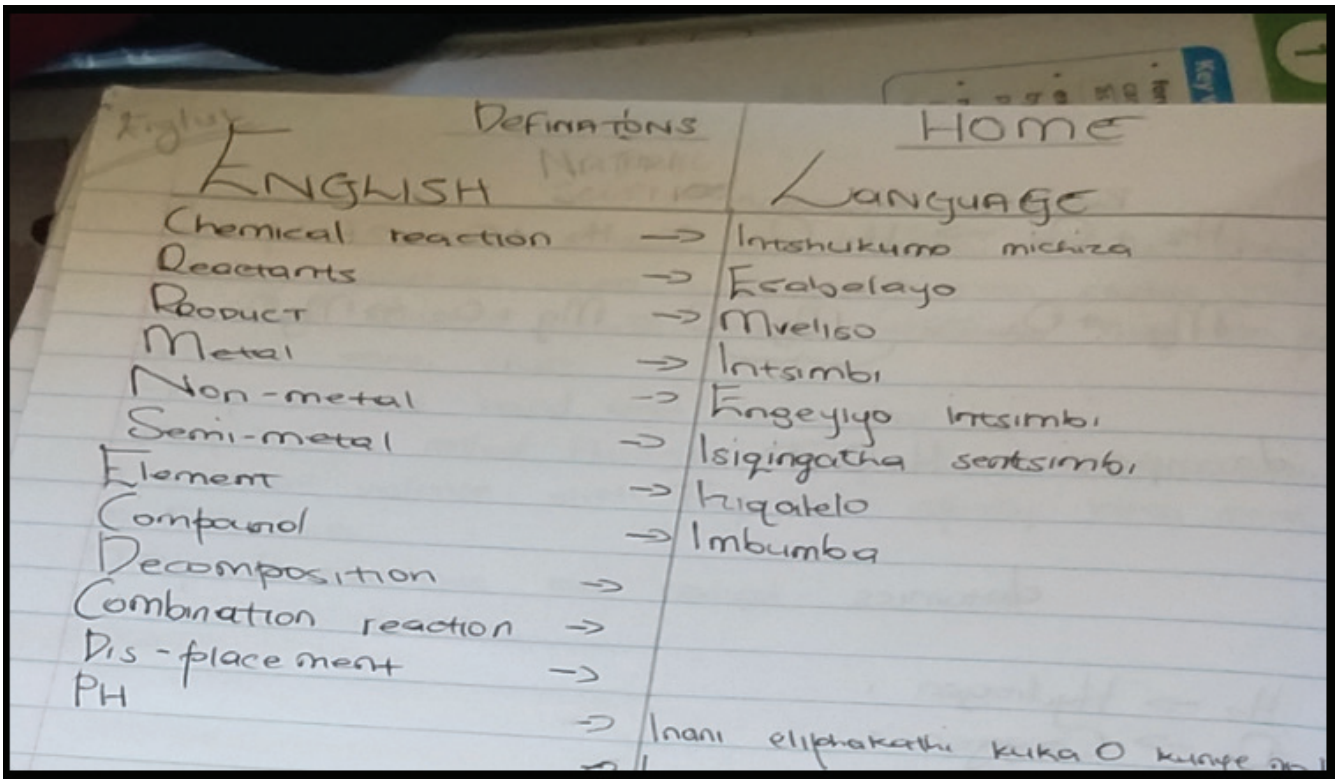
FIGURE 6: (a) Learner using cellular phone to create own bilingual glossary, (b) Learner using text books to create own bilingual glossary.

teaching and collaborative learning strategies in her classroom. Whereas before, she would teach learners using only English and the available textbooks, which were all in English, she now asked learners to work in groups, research the topics in the lesson units, create posters and bi/multiliteracy glossaries and then present their posters to the class.

When the learners had to do oral presentations, Mrs KM's guidelines for learners included the following:

- Learners were asked to present their bilingual research and work.
- They received feedback from classmates and the teacher.
- They could make corrections to their poster after the presentation.
- The final poster was placed on the wall as learning support material.

Mrs KM thus encouraged her learners to design and make bilingual posters and bilingual word walls. While Abdulatief and Guzula provided Mrs KM with paper and colourful pens for the learners' posters, the workshops and classroom support offered by the researchers gave Mrs KM the confidence to experiment with learner-centred pedagogies. Mrs KM gave the responsibility to learners to translate and develop terminologies using their own knowledge, bilingual dictionaries, and knowledge from their teachers and families (see Figure 7). As a Sesotho-English biliterate, she began trusting learners' use of isiXhosa in oral and written discourse. She also knew that she had limited proficiency in isiXhosa, and began trusting the dictionaries,



Source: L4L classroom observation, photo by Soraya Abdulatief

FIGURE 7: An isiXhosa and English glossary on chemical reactions from one of the learner's notebooks.

or confirming learners' responses with Guzula, other teachers at school, or with isiXhosa speaking teachers who participated in the workshops. Thus, she did not let her limited literacy in isiXhosa stand in the way of her learners' meaning making processes.

In Figure 8 (a transcript of a video recording - Extract 1), Mrs KM supports her learners by explaining key terms on chemical reactions from the poster in Figure 9 to the class.

Mrs KM elaborates on the poster presentation by a group of learners on chemical reactions by explaining the difference between compound name, common names and compound formula in both isiXhosa and English. Guzula, also present in the class on this day, affirmed Mrs KM's translation and translanguaging.

Extract 1 (see Figure 8) shows how Mrs KM started the discussion by asking the learners in the group and the whole class what the translation for the word 'compound' is in isiXhosa. The learners replied as a group, '*Imbumba* [compound]' and Mrs KM then restated the question, confirming their answer by saying '*Imbumba anhe?* [compound right, isn't it?]' then, the learners affirmed … saying in English, 'yes miss'. Mrs KM expands her explanation of the term 'compound' by translanguaging in both isiXhosa and English saying in turn 4 (Figure 8):

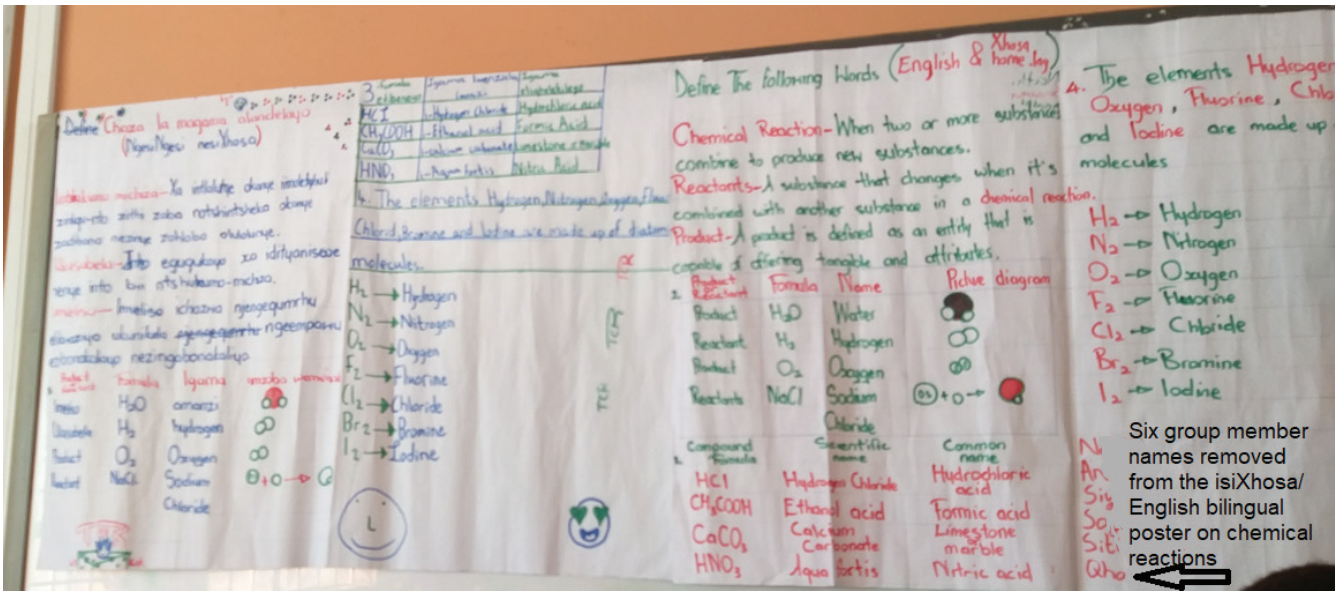
> 'That is a compound *yimbumba* [compound], two elements *izidibanileyo* [that are combined] *so ke ngoku xa kusithiwa kuwe kengoku* [so now when they say to you now] compound formula *uhh masenze eyiphi* … [which one should we do.]'.

Extract 1:

The teacher Mrs KM explains the differences between compound name, common name and the formulae

1. All learners: Imbumba [compound]
2. Teacher: Imbumba anhe? [compound right?]
3. Learners: yes miss
4. Teacher. That is a compound yimbumba [compound], two elements izidibanileyo [that are combined] so kengoku xa kusithiwa kuwe kengoku [so now when they say to you now] compound formula uhh masenze eyiphi... [uhh which one should we do..]
5. Researcher 1: That's a good name, imbumba[compound]!
6. Teacher: So imbumba [compound) because zimbini umzekelo apha [they are two, for example here] Hydrogen oxygen because intoni zidibene, siyevana? [what they are combined, do you get me?]
7. Learners: Yes
8. Teacher: ja that is a compound. Xa isithi iquestion [when the question says] write the compound name awuzubhala [you will not write] water, anel [right?] I-compound name yi hydrogen ne oxygen uzothini? [The compound name ishydrogen and oxygen, what will you say?] Hydrogen Oxide. So there is a compound name, there is a common name, there is formula zohlukile zingakubhidi pha xa ubhala kwi exam [they are all different, don't get confused when writing your exam], funeka uyazi iqestion ithini ngoku [you should know what the question says], ifuna icompound name [does it require compound name], ifuna i-compound formula [does it require compound formula], ane? [right?] Then ifuna i-chemical formula [then it wants a chemical formula], chemical symbol zezozinto sizidivayidayo apha, ane sibenomehluka wazo [it is those things we divide here, right to know their differences]. Sinawo umbuzo? [Do we have a question?]
9. Learner. No
10. Teacher. Ingathi asinawo umbuzo nhe, sicela igroup elandelayo [it looks like we do not have a question, can we have the following group].

FIGURE 8: Extract 1 from Mrs KM establishing scientific precision in isiXhosa and English for the learners.



Source: L4L classroom observation, photos and compilation by Soraya Abdulatief

FIGURE 9: Two learners co-presenting the English-isiXhosa bilingual posters on chemical reactions created by the learners: (a) Learner (left) presented the IsiXhosa poster in isiXhosa (b) Learner presented the English poster in English.

Thus, she explains that a compound is two elements that are combined in a hybrid register (Figure 10). Guzula affirms saying 'That's a good word, *imbumba* [compound]!'. Mrs KM continues her explanation by repeating 'So *imbumba* [compound] because *zimbini umzekelo apha* [they are two, for example here] Hydrogen oxygen because *intoni … zidibene, siyevana*? [what … they are combined, do you get me?]'. In turn 6, the learners respond 'Yes'.

Here Mrs KM not only prepares learners for exams by explaining the terms that can be confusing, but she emphasises scientific precision by differentiating between scientific register and everyday discourse. She explains that water is a common everyday name, H_2O is a formula, while hydrogen-oxide is a compound name. The teacher and learners have already established that, in isiXhosa, a compound is *yimbumba* (which means to be one, unity or combined) and that hydrogen and oxygen combine to form *imbumba* which is hydrogen-oxide. However, because Mrs KM is Sesotho speaking, she misses finding existing

Source: L4L classroom observation, photo by Soraya Abdulatief

FIGURE 10: Mrs KM using a learner poster to revise and restate some of the definitions.

isiXhosa terms for hydrogen and oxygen as separate chemicals. Oxygen is known as *umongo-moya*, while

hydrogen is *ihayidrojini*. But since the learners have been taught to work independently in groups to search for the meanings of scientific terms, it is possible that the learners will put these words into their glossaries.

Extract 2: Teacher 'take-up' and development

In Extract 2 (see Figure 11), which takes place after a life science lesson on the alimentary canal with the same group of learners months later, we analyse how Mrs KM refined the practices that she had learned. We also analyse the benefits of translation and acknowledge the cognitive demands on the learners as bilingual learners who are building competency in two languages.

Mrs KM's reflection about her practice shows that she has figured out her own strategies independently of the mentors or researchers. She implemented the first strategy, which she describes as allocating learners to groups, and giving them a page from the English textbook to work on and translate into isiXosa, using a dictionary. She also reflected that the learners found this method difficult, and her new method thus included designing questions for each group with learners reading the textbook and conducting their own research to find the answers. Thus, she engaged in reflection-on-action and positioned herself as a competent reflective teacher who can make independent professional judgements considering the availability of resources and classroom realities.

A lack of resources could be the reason learners found the first method of translating whole pages from the English textbook difficult, as there were only two multilingual science dictionaries available in a class of 45 learners. If there were 9 groups, 7 groups would have to wait patiently for their turn. However, the preferred question-and-answer method meant that learners could exercise agency, explore the meanings of words, and discuss them in their groups while waiting for the use of a dictionary. Also, the dictionaries may not have the terms learners needed, as the authors of each dictionary selected words from the science curriculum that were deemed important for Grades 4 to 12. Sometimes the isiXhosa word did not even exist in the science dictionaries, and the isiXhosa word was found in a generic language dictionary Guzula had brought to the classroom. For example, for the circulation system, the isiXhosa words for 'capillaries', 'veins', 'arteries', 'vessels', et cetera, were available in the general language isiXhosa-English dictionary and not in the science dictionaries.

Extract 2:
Mrs KM explains how, after making a significant shift from traditional teacher-centred pedagogy to learner-centred pedagogy, she further refined the learner-centred pedagogy

1. In groups, in groups of 6 to 8. So when I was giving them that kind of work, I was saying this first group must do page 1 for instance then second group must do page 2, third group must do page 3, then I have two dictionaries in my class so I would uhm, give the dictionaries to them so
5. they can exchange between the groups. Each and every word must be written in home language as well as in English, so this year I have improved the way which I have done, sorry this term... sorry this term in term two, I have improved. What I am doing, I... uhm I'm giving the learners the questions for instance uhm, uhh, write the word, define the
10. word alimentary canal, and write down the components of the alimentary canal, define the word digestion. So I communicate with them, I ask them which way is the better? When I say do page 1 or when I give you questions? They say to me 'It's better miss when you are giving us the question'. I thought that the question part is going to be difficult because
15. when I give the question without a dictionary, I give them the question and they must write the same question in English as well as translate the same question in home language. They must also write the answer in English and write the same answer in home language, so they are doing that. Er... each and every word they must make sure that it's in both languages. So
20. I found that this part is gonna be difficult when I give them the question, they understand more than the first part, I'm even improving my way of teaching... the strategies of teaching thanks to Zenex!

FIGURE 11: Extract 2 indicating the interview responses that shows teacher 'take-up' and development.

The fact that not all isiXhosa words were available in the dictionaries meant that the researchers, the teacher, and learners engaged in both translation and terminology development processes. Translation and terminology development therefore not only requires the use of two languages, but also thinking and tapping into existing knowledge in both languages and with reasoned support for the terms. Thus, translation and terminology development are cognitive processes and competencies that the learners developed during the classroom support which deepened their understanding of the new concepts. When the L4L project leader, Margaret Probyn, was told about the shortage of dictionaries, she arranged for more isiXhosa-English science and mathematics dictionaries to be bought and delivered them to teachers at the participating schools.

Conclusion

In this article, we have focussed on answering the research question: 'What bi and multilingual pedagogical practices, in the cycle of change implemented by the L4L project, were used to support both teacher and learner oral and written language development in Grade 8/9 Science?' To challenge monolingual ideology and the dominance of English, we drew on a socio-cultural approach to language, literacy, and learning. We discussed the importance of language in learning for both learners and in the professional development of teachers. We also drew on decolonial theory, and the legitimation of African languages, translanguaging, translation and other multilingual practices that involve 'giving voice to that which has been silenced and erased' (Mignolo 2007:463). We showed how the cycle of change contributed to Mrs KM's development and 'take-up' of bilingual strategies and approaches in her natural science and life science teaching. We discussed the factors that contributed to the take-up of bi/multilingual strategies which included the following: supported teacher development with researchers engaging as both researchers and mentors that facilitated reflections; group teacher training workshops; demonstrations and learning from peers; and classroom support. We noted how learner development and positive responses motivated and inspired the teachers to do more. This resulted in teacher-led initiatives, for example Mrs KM made independent professional decisions shaped by classroom practice. The availability of material resources (dictionaries and Learning and Teaching Support Material [LTSMs such as paper and

colour pens]) and access to mentors, also contributed to Mrs KM's motivation to try bi/multilingual pedagogies. Teaching bilingually resulted in learner openness to working bilingually and increased their participation and engagement. There were learner-centred activities with learners doing research, and through translation, learning science in isiXhosa and English. There was an increase in learning material in the form of learner posters on walls. Dictionary work and learner-centred teaching developed the learners' metalinguistic skills as learners engaged in translation and terminology development and sharpened their translation skills. Finally, evidence of bilingual writing on posters for the classroom as well as in learners' written notes showed a rich print environment or linguistic landscape in the science classroom.

Mrs KM and the learners' spontaneous oral translanguaging, developed into designed pedagogical translanguaging with the deliberate use of isiXhosa in oral and written form, demonstrating its legitimacy for learning science. In crossing the frontiers from oral to written language, the status of isiXhosa in the eyes of the teacher and learners increased, as isiXhosa became recognised as a language of teaching and learning alongside English. The bi/multilingual strategies designed and implemented by the researchers, the teacher, Mrs KM, and the learners as discussed above, are important for new teachers and can be integrated into teacher education that works towards social justice in education.

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Authors' contributions

S.A. and X.G. contributed equally to the research, analysis, writing and development of this manuscript.

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Data availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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