International Journal of Science Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tsed20

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To cite this article: Erasmos Charamba (2020): Translanguaging in a multilingual class: a study of the relation between students' languages and epistemological access in science, International Journal of Science Education

To link to this article: https://doi.org/10.1080/09500693.2020.1783019

Published online: 03 Jul 2020.

INTERNATIONAL JOURNAL OF SCIENCE EDUCATION
https://doi.org/10.1080/09500693.2020.1783019

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Translanguaging in a multilingual class: a study of the relation between students' languages and epistemological access in science

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ABSTRACT

This study describes multilingual students' authentic use of their multiple languages in a science classroom in Viljoensdrift, South Africa. There has been a broad scope of research conducted by several researchers with regards to translanguaging and all have proven it to be an effective pedagogical tool that can be used in the process of teaching multilingual students universally. The studies showed that translanguaging can be used to break the common notion of monolingual bias to eradicate the disadvantages it inflicts on multilingual students. This present mixed-methods study involves 28 eighth-grade high school Natural Sciences students whose home language is Sotho. The participants were taught in both English and Sotho and were given tutorial materials written in their home language. After the lessons, the participants wrote a post-test and were also interviewed on their experiences of the translanguaging pedagogy and learning materials they used. The post-test results and interview responses highlight the significant role played by students' home language in the science classroom, illustrating the ways in which translanguaging in a science classroom constitutes a resource in joint negotiations of the scientific content and its related language for multilingual students.

ARTICLE HISTORY
Received 22 September 2019
Accepted 11 June 2020

KEYWORDS
Multilingualism; translanguaging; science education

Introduction

The release of the 2015 Trends in International Mathematics and Science Study (TIMSS) reports for fifth and ninth-graders provoked once more another storm of debates as South Africans grapple with the reasons behind the perceived poor performance in mathematics and science (Charamba, 2019b; Reddy et al., 2016). TIMSS is an assessment of the mathematics and science knowledge of fourth and eighth-grade students from selected countries around the world. South Africa participates in fifth and ninth grades (Reddy et al., 2016).

It is important to emphasise the issue of selected countries for accurate interpretation of the reports as only 39 countries participated in 2015 for eighth grade and 48 countries participated at the fourth-grade level. TIMSS uses the five 'international benchmarks' to scale the scores, namely: Advanced (above 625 points), High (550–625 points), Intermediate

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(475–550 points), Low (400–475) and Not Achieved stands at less than 400 points (Reddy et al., 2016). For South African context, the Human Sciences Research Council (HSRC) introduced an additional benchmark, Potentials, for the scores between 325 and 400 points to identify the group of students that can be targeted for upward shifting to a higher benchmark (Charamba, 2019b; Reddy et al., 2016).

As a result, the Not Achieved benchmark is for less than 325 points as opposed to 400 in a local context. At the ninth-grade level, the national average score for the country is 358 points for science (39th position out of 39 countries). For BRICS countries, another country that participates in TIMSS is the Russian Federation and 14% of its students achieved at Advanced level for this grade, 32% achieved at High level, another 32% at Intermediate level and 17% achieved at Low level. South Korea came 3rdwith 43% of its students achieving at Advanced level and 32% at High level (Charamba, 2019b; Reddy et al., 2016). The low performance of South African students for mathematics at grades five and nine (and science at grade nine) is linked to the factors at home, school, and community environments, but chief among them is the language of instruction used in schools (Parliamentary Monitoring Report, 2017; Reddy et al., 2016).

In analysing science results in the country, Umalusi, South Africa's quality assurance body on education, also suggested that the underachievement by most students is caused by the monolingual bias which results in students being taught in a single language they have limited proficiency in (Charamba, 2019b; Reddy et al., 2016). These students experience great difficulties in understanding the concepts, interpreting questions and drawing up responses leading to Umalusi calling for the adoption of a multilingual pedagogy in the country's linguistically diverse classrooms (Parliamentary Monitoring Report, 2017; Reddy et al., 2016). Although South Africa has 11 official languages (English, Afrikaans, Sesotho, Sepedi, siSwati, Xitsonga, Setswana, Tshivenda, isiNdebele, isiXhosa, and isiZulu), more than 80% of schools in the country use English as the language of instruction from the fourth-grade upwards (Statistics SA, 2017). From grade R till the third-grade students in South Africa are taught in their home language alongside English (Charamba, 2019b). In South Africa, grade R is a class below first- grade and normally enrols students aged five.

There is consensus among researchers in science education across the country (see for example Charamba, 2017; 2019b; Childs, 2016; McKinney & Tyler, 2019; Msimanga & Lelliott, 2014) and across the globe (see for example Ollerhead, 2019; Ramirez & Ross, 2019; Zavala, 2019) that monolingual pedagogy is one of the major causes of low academic performance amongst multilingual science students. This body of research suggests the most efficient strategy for teaching multilingual science students is for teachers to acknowledge, accommodate, and use students' multiple languages in the classroom so that they become competent multilinguals without sacrificing English development (Charamba, 2019a; Gu, 2015). Results of research by Charamba (2017, 2019b) show improved academic performance among eleventh-grade Physics and tenth-grade Chemistry students when Sotho is used alongside English language during science instruction. But how efficient is translanguaging in an eighth-grade class where all students are native Sotho speakers and taught in English? There is little, if any, research on the efficacy of using these two languages in South African eighth-grade Natural Sciences classrooms. The present study, therefore, joins a body of research that focuses on translanguaging in science classrooms but with a focus on a South African eighth-grade class whose home language is Sotho and is taught in English.

The top-performing countries in the 2015 TIMSS assessments use their local languages as languages of instruction (Reddy et al., 2016). This is in line with findings of recent studies in the global south by UNESCO which also suggest that one of the major causes of learners' academic underachievement is the use of monolingual pedagogy where the language of instruction is different from their home language (UNESCO, 2016). This aligns with findings by several other researchers that the language of instruction does play a pivotal role in students' academic achievement in cases where the language of instruction is different from their home language (McKinney & Tyler, 2019; Ollerhead, 2019; Ramirez & Ross, 2019; Somerville & Faltis, 2019; Zavala, 2019).

Theoretical framework: learning as action and the translanguaging theory

In this study, multilingual students' learning in Natural Sciences has been examined from a pragmatic perspective (Dewey, 1998) and by using the theory of translanguaging. In both theories, language and learning are regarded as actions situated in a historical, cultural and social context irrespective of the content area. A pragmatic perspective on learning has enabled an analysis of language (McKinney & Tyler, 2019), gestures and physical artefacts by focusing on their use and consequences in a specific context such as a school (Ollerhead, 2019) while translanguaging looks at the use of multiple languages, often simultaneously (Jakobsson & Davidsson, 2012; Ramirez & Ross, 2019), The theory of translanguaging has provided knowledge about the multiple discursive practices in which bilinguals engage in order to make sense of their bilingual worlds (Charamba, 2019a; Gee, 2015). According to Dewey's theory (1998), this experience (of using multiple languages) is not a representation of the external world, and it is more than an internal process taking place 'inside' individuals (Gu, 2015). Dewey views the interaction between the individual and the surrounding context as an inseparable unit. According to Dewey's principle of continuity, learning is a process intimately related to meaning-making (Charamba, 2019a).

Meaning-making always involves learning, which in turn amounts to establishing relations between immediate entities of experiences (Somerville & Faltis, 2019). In the science classroom, this meaning-making process takes place through various discourses. Natural Sciences students make meaning of new situations by relating to their earlier experiences and the purpose of the activity (Ollerhead, 2019). Concomitantly, the meaning-making process also involves acting in the situation and reflecting on the consequences of actions (Wei, 2018). The combination of action and reflection results in learning, which in turn is a transformation of earlier experiences (Henderson & Ingram, 2018) into new ones. Science learning concerns developing new patterns of actions to make meaning of different situations (Charamba, 2019b), or habits as Dewey defines it (Dewey, 1998).

When applied to the science classroom context, teachers need to create social and physical situations resulting in educative experiences by observing how students' experiences are growing and direct them towards the goal of the particular academic activity (Karlsson et al., 2018) because students make meaning of science classroom activities by drawing on their earlier experiences. Teachers cannot regulate, at least not in the current situation, what kind of experiences students enter the classroom with (Charamba & Zano, 2019; Ramirez & Ross, 2019). Therefore, the ultimate concern for science teachers is making

students' earlier experiences continuous with the lessons they deliver (Dewey, 1998) in the current science classrooms. Learning can never be only a question of students' biologically-given capacity to learn (Zavala, 2019), instead earlier knowledge and proficiencies need to be related to the context in which the lessons take place (McKinney & Tyler, 2019; Somerville & Faltis, 2019). This involves science teachers paying attention to how students cooperate with other individuals and the use of different intellectual, physical, and linguistic resources (Vygotsky, 1978).

Viewing learning as action, inseparable from the context in which it occurs enables the avoidance of extremes in educational research; studies examining students' learning as a cognitive process (Ollerhead, 2019; Ramirez & Ross, 2019), regardless of situational aspects, and studies focusing on the environment by regarding students as passive recipients (Cunningham, 2019). When science learning is regarded as situated action, taking place in interaction with others and the surrounding context (Charamba & Zano, 2019), communication gains a central role (Song, 2019). When communication occurs in the science classroom, events gain meaning, sounds turn into language, body movements into gestures and symbols into a written language (Choi et al., 2019) resulting in fruitful meaning-making.

Language and other actions used to communicate do not have fixed or universal meanings and exist on their own. They gain meaning through their use and consequences in a specific context (Fránquiz & Ortiz, 2018). Communication, both in general and in science class, involves the use of a range of resources, all contributing to students' learning in specific ways (Karlsson et al., 2018). As in pragmatic (Dewey, 1998) and sociocultural approaches (Vygotsky, 1978), language is viewed as an activity produced by social relations rather than a simple system of structures giving us a set of skills (Wei, 2018) and in the science classroom this can also be viewed through the translanguaging lens.

Translanguaging for epistemological access: theory and practice

The term translanguaging was initially coined by Cen Williams when referring to a pedagogical practice in which bilingual students use both of their languages (Stroupe et al., 2019). For instance, the students are asked to read in one language, for example, English and write about their reading in a different language, for example, Sotho (McKinney & Tyler, 2019). Today, translanguaging has been extended and is used by scholars within the bilingual field to describe the complex language practices of bilinguals (Charamba, 2019a; Garcia, 2014). Although several definitions of the term exist today, they are all grounded in the idea that bilinguals' languages are intertwined, belong to the same linguistic repertoire and support learning in one way or the other (Childs, 2016).

The original translanguaging model was expanded by Ofelia Garcia to include all discursive resources that can best be explained as more like an all-terrain vehicle whose wheels extend and contract, flex, and stretch, making possible, over highly uneven ground, movement forward that is bumpy and irregular but also sustained and effective, (Garcia, 2014). Key to this metaphor is that the process of translanguaging, especially in education, may look fuzzy and murky from the hearer's point of view, as the all-terrain vehicle may be to an onlooker, but its outcomes are effective for the speakers to make sense of the world and of who they are in the same way that the all-terrain vehicle effectively completes its complex task (Makalela, 2018). The following definition of

translanguaging by Garcia and Wei (2014, p. 3) suggests the emancipatory nature of this practice and its facility to disrupt the linguistic power imbalances in the Natural Sciences classroom:

> Translanguaging in education can be defined as a process by which students and teachers engage in complex discursive practices that include all the language practices of students in order to develop new language practices and sustain old ones, communicate and appropriate knowledge, and give voice to new socio-political realities by interrogating linguistic inequality.

This view of translanguaging in the science classroom makes it possible to have an unsegregated (Ramirez & Ross, 2019), blanket pedagogy that affirms all pragmatic modes (Henderson & Ingram, 2018) that multilingual students bring with them into the science classroom (Zavala, 2019) to advance their cognitive, linguistic and literacy skills (McKinney & Tyler, 2019) that include other digressive resources such as note-taking (Ramirez & Ross, 2019), sighing, peer to peer talk (Wei, 2018), and discussing to make sense of learning (Charamba & Zano, 2019), as symbolised by the all-terrain vehicle (Garcia & Wei, 2014). It is within this framework that modern-day science educators need to show and use their natural translanguaging practices in the classroom by moving away from monolingual practices which render them irrelevant to the twenty-first century (Zavala, 2019). In this regard, translanguaging in the Natural Sciences classroom is not about the usage of separate languages in education (McKinney & Tyler, 2019) but rather, it is the flexible and meaningful actions through which bilinguals select features in their linguistic repertoire in order to communicate appropriately (Velasco & García, 2014).

Basing on recent research, teachers who adopt translanguaging pedagogies in science education, particularly in cases where the medium of instruction is different from the students' home language engage in a democratic endeavour for social justice (Karlsson et al., 2018; McKinney & Tyler, 2019), because they do not undermine the students' right to learn in a language of their choice or that with which they are most familiar (Charamba, 2019a; Msimanga & Lelliott, 2014). As such, translanguaging in the science classroom can be viewed as a classroom ecological approach (McKinney & Tyler, 2019; Ollerhead, 2019) where the teacher creates interactive lessons with the languages not rigidly separated (Charamba & Zano, 2019; Ramirez & Ross, 2019) but used in a flexible and concurrent fashion for the benefit of the student (Stevenson, 2013).

Furthermore, translanguaging is not limited to language; it also involves other mediating means bilinguals use alongside their languages to communicate (Howe & Lisi, 2014; Rogers, 2014). Translanguaging concerns the act of languaging (Velasco & García, 2014), which is inseparable from the social, historical and institutional context in which it occurs (Wei, 2018). Human beings are viewed as social actors moving along various socially constructed languages and construing relations between their everyday languaging and school languaging (Charamba & Zano, 2019; Henderson & Ingram, 2018). The process of learning and/or using a language is viewed to imply integration (Charamba et al., 2019; Rogers, 2014). Regardless of whether it concerns a national language or an academic one, what is learned needs to be related to students' already existing language practices (McKinney & Tyler, 2019).

Rather than learning a 'new' or a 'second' language (Somerville & Faltis, 2019), multilingual students are developing their own and unique repertoire of resources, enabling

them to make meaning of their worlds. Seen in this way, language practices do not belong to the home or school (Charamba, 2019a). A language practice can only be developed by deriving from what is already known (Ramirez & Ross, 2019), that is, students' existing language practices (Gee, 2015). Accordingly, using translanguaging as an educational pedagogy in the Natural Sciences classroom offers students increased possibilities for linguistic development and content learning (Rita, 2016). Multilingual students are able to access academic content with the resources already part of their repertoire, while simultaneously acquiring new ones (Garcia & Wei, 2014).

The questioning of the monolingual view of multilingualism and the emergence of the theory of translanguaging has resulted in researchers paying attention to multilingual education, that is, the inclusion of multilingual students' minority languages at school and in other educational settings (Rogers, 2014). Multilingual education is of importance for linguistic development as well as students' overall academic achievement (Wei, 2018). A well-developed minority language is viewed as facilitating the learning of a society's majority language and supports students' overall achievements at school (Henderson & Ingram, 2018).

In South Africa, education for multilinguals is still typically conducted monolingually in the majority language (Charamba & Zano, 2019; Childs, 2016). A frequently used argument among teachers and policymakers is that giving time to students' minority language at school risks negatively affecting the development of the majority language (Charamba et al., 2019). It is said that allowing students to speak their minority language implies less use of the majority language, and hence less practice (Wei, 2018). However, researchers are agreed on the opposite: including multilingual students' minority language at school does not obstruct or delay the development of a majority language (Ramirez & Ross, 2019; Somerville & Faltis, 2019; Velasco & García, 2014; Wei, 2018) but rather supports the development of the majority language. Rejecting multilingual students' use of their minority language implies that the students can only use a limited part of their resources to make meaning of the lessons (Henderson & Ingram, 2018; Howe & Lisi, 2014).

Research questions

The study sought to answer the following questions:

1. How does the use of one's mother tongue affect the academic performance of eighth-grade Natural Sciences students?
2. To what extent can Sotho be used to facilitate the teaching/learning of Natural Sciences?

Materials and methods

This section details the methods and materials used to collect and analyse the research data.

Participants

There has been no major empirical study of dual-language or 'two-way' programmes, those that mix English language and African languages in roughly equal proportions

with the objective of fostering full bilingualism and biliteracy with a focus on science education (Probyn, 2015). Recent studies, however, suggest that this is the most effective strategy for educating students whose home language is different from the school's medium of instruction to become competent bilinguals without sacrificing English development (Ramirez & Ross, 2019), science teaching/learning, and their home languages (Karlsson et al., 2018; Stevenson, 2013).

The study was informed by the developing proficiency of most eighth-grade science students in the medium of instruction (English) at the school involved in the study (Charamba, 2019b). One Natural Sciences class at a high school in Viljoensdrift was chosen to participate in the research. The class comprised of 28 students and they all participated in the study. The school has five eighth-grade classes and the participating class is ranked fifth in terms of academic performance in Natural Sciences and English language, the reason why it was purposefully sampled for the study. Due to their low proficiency in the language of instruction (English) and academic underachievement in Natural Sciences, the study sought to explore if translanguaging and bilingual learning resources would have an impact in the students' academic performance.

The school is a public school, fully funded by the South African Department of Education because the majority of the parents are in the low- income bracket. For these parents and their children, English is either their second, third or even fourth language (Charamba, 2019b). According to students' profiles obtained at the school, all students who participated in the study are native- Sotho speakers. Regarding the socioeconomic status of most parents in Viljoensdrift, most children in the area find themselves receiving their primary and secondary education in one of the public schools where all the teachers are also native speakers of one of the nine official African languages (Charamba, 2019b). In these public schools, children are educated through their mother tongue from grade R to the third-grade (Charamba, 2017). From grade 4 onwards the medium of instruction in Viljoensdrift is English language (Charamba, 2019b).

The research adopted a sequential explanatory design (QUAN → qual) where the quantitative data were collected and analysed first before the collection and analysis of qualitative data (Creswell, 2014). Considering the participants' ages, consent was sought from their parents. All ethical considerations were observed. The participants were informed that participating in the study was not compulsory. They were also informed that if they chose to partake in the study they were free to withdraw from the study at any time without any repercussions. To protect their identities, participants were randomly assigned numbers to replace their names. They were referred to using those numbers throughout the study.

Data sources

Pre-and post-test

The participants wrote the Natural Sciences pre-test first and then the post-test was written after the translanguaging- informed intervention. The participants were randomly assigned numbers with which they were referred to during the course of the study. The pre-test was written in English language whereas the post-test was in the two languages (English, and Sotho). Each test had 15 multiple choice questions with 4 possible

answers per question and the duration for each test was 30 min. The tests were developed in line with the aims of the study by the researcher in consultation with the subject teacher and respective subject specialists at the Fezile- Dabi Department of Education district offices.

In South Africa the role of the subject specialists is to perform four basic functions: selecting and distributing learning resources, assisting teachers with advanced subject inquiries including professional development, overseeing the teaching and assessment of students in their respective learning areas, and maintaining liaisons with relevant academic departments in other districts around the province. In the present study, the subject specialists were involved in drawing up suitable assessment tools because of their invaluable expertise. During the intervention phase participants were given a bilingual English-Sotho Natural Sciences dictionary and were also allowed to use their home language during lessons. The translanguage- informed lessons were conducted by the Natural Sciences teacher two days a week for four weeks in the presence of the researcher. Each lesson was 40 min long.

The lessons were on *Life and Living*, a topic that explores the characteristics of living and non- living things. Participants were also given academic tasks to do in their groups and were allowed and encouraged to use their mother language during the discussions. Although discussions were done in Sotho the final responses to be presented to the class were translated into English, the school's language of instruction.

Below (Excerpt 1) is an extract from the bilingual English- Sotho Natural Sciences dictionary:

Excerpt 1:

Excreting … … … … … … *Hohlahlisa*
Hibernate … … … … … … . *Pata*
Plants … … … … … … … … *Limela*
Offspring … … … … … … .. *Bana*
Reptiles … … … … … … … . *Lihahabi*
Stems … … … … … … … *Lipalo*

The dictionary also had translations of some phrases, for example:

We call these the seven life processes.
Re bitsa tsena mekhoa e supileng ea bophelo.

As alluded to earlier, the post-test questions were in both languages, English and Sotho. Excerpt 2 below is an extract from the post-test:

Excerpt 2:

(1) A river seems to move, so is a river living?

Ho bonahala eka nōka e falla, le nōka e phela?

(1) A chicken egg seems to be non-living, but then it can hatch into a chicken. Is the egg living or non-living?

Nama ea khōhō e bonahala e se ea phelang, empa e ka qhoma ka har'a khōhō. Na lehe le phela kapa ha le phele?

(1) Are the plants that I eat from my grandmother's garden living or non-living?

Ke limela tseo ke li jang serapeng sa gogo sa phelang kapa sa phelang?

Data analysis

Qualitative data were analysed using qualitative data analysis, an approach grounded in Glăser and Laudel's (2010) model that produces an information base that is structured by categories and can be used in the subsequent search for patterns in the data and integration of these patterns into a systematic (Charamba, 2019a), theoretically embedded explanation (Glăser & Laudel, 2010). Quantitative data were analysed using descriptive statistics through univariate analysis (Creswell, 2014) as the study sought to measure cause and effect to draw conclusion between two variables, language use being the independent variable and students' academic performance being the dependent variable (Charamba, 2019a). Measures of central tendency and dispersion were calculated for each test and analysed (Creswell, 2014).

Results

Pre-test

The test comprised 15 multiple choice questions with 4 possible answers per question. 4 of the students got 1 out of 15 for the pre-test with 6 scoring 2 out of 15; 11 got 3 out of 15 and 1 got 4 out of 15. According to the South African Department of Education's pass requirements for eighth-grade students (where 30% is considered a pass), 22 of the 28 students scored below the pass mark in the test. 3 of the 28 students got 5 out of 15; 2 got 6 out of 15 and the highest student got 7 out of 15. 6 out of 28 students passed the pre-test representing a pass percentage of 21.4%. The class had an average score of 3.1 out of 15 (20.7%) for the pre-test. According to the students interviewed the major problem impacting their academic performance is the language used in the classroom and found in texts and assessments (Charamba, 2019a). Below is an excerpt from one of the students interviewed:

Excerpt 3

The questions were hard because the language is difficult. The teacher explained the work but still, I didn't understand it because I am always failing English.

An interesting contribution came from student 22 who said:

Excerpt 4

N.S [Natural Sciences], S.S [Social Sciences], EMS [Economic and Management Sciences] and Technology are all the same. If you don't know English you won't pass them.

Analysing the second excerpt, Student 22 and many like her hold the view that academic success in the 4 learning areas listed above is directly proportional to one's proficiency in the English language since it is the medium of instruction. After writing the pre-test students were given translanguaging – informed intervention, after which they wrote a post-test.

Post-test

The post-test, like the pre-test comprised 15 multiple choice questions with 4 possible answers per question. The lowest score obtained in this test was 4 out of 15. This was attained by 2 students and the highest mark was 13 out of 15. The class had an average score of 7.9 out of 15 (52.7%) and a pass rate of 75%. Although the marks were not very high, there was a significant improvement in the students' academic achievement compared to their performance in the pre-test. Considering the fact that the class had an average of 3.1 in the pre-test, the results of the post-test (in which the class average was 7.9) are encouraging. 21 out of 28 students achieved a pass for the post-test compared to only 6 in the pre-test. The results of the post-test suggest that 15 students performed better than they had done in the pre-test. This in itself might suggest the efficacy of translanguaging-informed intervention used during the science lessons.

After having analysed the post-test results, the researcher went on to interview 14 of the participants. To ensure variation, those to be interviewed were purposefully chosen. The researcher chose students who had exhibited varying linguistic practices during the study as well as those whose performance in the two tests was significantly different. The aim of interviewing the participants was to establish meanings or essence of a lived experience among the participants, how they experienced the lessons, the English- Sotho Natural Sciences dictionary and, lastly, the meanings that they (interviewees) attached to the learning experience (Charamba, 2019b). Presented below are sample questions from the interview schedule:

1. Did you find the English- Sotho Natural Sciences dictionary useful? Explain your answer.
2. Do you think being taught Natural Sciences in your home language makes any academic difference? Provide reasons for your answer.

The interviews were conducted in English and responses were written and tape-recorded concurrently by the researcher ensuring data was captured accurately for analytical purposes. Each participant was asked 5 questions, in the same order and wording with each interview session lasting an average of 30 min.

In analysing qualitative data from the interviews, both coding and qualitative content analysis were used to produce an information base, which was further analysed in order to answer the research questions (Glăser & Laudel, 2010). The use of both methods ensued each complemented with the weaknesses of the other. The researcher fused both methods adopting a reductionist approach in which the data was re-read several times to arrive at themes until saturation points were reached (Charamba, 2019a). The themes are supported by prototypical verbal reports from the students who were interviewed.

The main themes that emerged from the analysis of learners' interview responses were:

Theme 1: Role of language in academic performance of eighth-grade Natural Sciences students.
Theme 2: Effect of Natural Sciences learning materials written in students' home language.

Role of language in academic performance of eighth-grade Natural Sciences students

During the interviews, 10 of the 14 students indicated that they underperform in Natural Sciences and other learning areas because of the language of instruction. Even though teachers try hard to explain the concepts and use multimedia, all this is done in a language the students have low proficiency (Rita, 2016). All students in the present study are native Sotho speakers, English being a second or third language. Presented below are excerpts from interviews held with the students:

Student 13 had this to say:

Excerpt 5

I liked the last test. I could understand the questions clearly. The first test was actually difficult and the language used, eish, was deep and too scientific.

Student 4 said:

Excerpt 6

The last one was very easy. It was the first test that gave me problems. It was too hard and I couldn't understand the language sekgowa [English]. It was difficult for sure.

On being asked why he (Student 13) found the post-test easier than the pre-test, the student said:

Excerpt 7

The use of Sotho in the lessons and also that dictionary helped me a lot. My marks for the second test were higher than the first test because of the use of Sotho, it's my mother tongue and I understand it.

The same follow-up question was given to Student 4 whose response was:

Excerpt 8

I give thanks to my teacher for giving me a dictionary in my mother tongue. It explained words I didn't know well. I got very high marks in the second test because of the lessons in my language and the dictionary.

When asked about his academic performance during the study, Student 17 shared a similar view to that expressed by the other two students and said:

Excerpt 9

My highest mark was for the last test. Using my language in the lessons helped me a lot. I was able to understand and follow what was happening in class. My English isn't good at all so the language [Sotho] helped me.

In line with what some of the participants said (see for example Excerpts 7;8;and 9), during the lessons the researcher witnessed numerous cases in which these science students and their teacher would make use of their entire linguistic repertoire during class and collaborative group discussions. For example during a class discussion on differences between living and non-living things:

Excerpt 10

Student 2: All living things move from one place to another.

Student 11: *Ke a hana. Limela ha li tsamaye empa* they are living.

Teacher: What do others think? *Ba bang ba nahana eng*?

Student 9: It's true, *limela ha li tsamaye empa lia phela*.

Student 17: Living things *li hloka metsi* to survive.

Student 23: *Ho thoe'ng haeba e le komello*? They will die?

Teacher: Correct. Living things need water to survive. They use it for drinking, *ho etsa lijo tsa bona, le joalo ka tšireletso*.

In Excerpt 10, Student 2 answers in English stating that all living things move from one place to another. Student 11 quickly points out that she disagrees with that answer (*Ke a hana*) and goes on to explain that plants do not move (*Limela ha li tsamaye empa*) but they are living. The teacher, at this point, does not get involved in the scientific discussion but rather asks the rest of the class what they think (*Ba bang ba nahana eng*?). Following Student 11 and the teacher's use of more than one language, Student 9 joins the discussion by first stating in English that 'it is true' and gives the explanation in Sotho that 'plants do not move but they are living things' (*limela ha li tsamaye empa lia phela*). Student 17 adds to the discussion by pointing out that all living things need water (*li hloka metsi*) to survive. In Sotho, Student 23 asks what will happen if there is a drought and living things do not get water (*Ho thoe'ng haeba e le komello*?) and then presents the last part of his question in English (They will die?). The teacher then joins the scientific discussion pointing out that living things do need water and goes on to give some of the uses of water in English and Sotho.

Excerpt 10 shows that language and learning are intertwined and regarded as actions situated in social contexts regardless of the learning area. Even though students were translanguaging that did not change the scientific correctness of what they were saying. Similar cases of translanguaging were observed throughout the study. All students in the study come from linguistically hybrid townships where they speak a variety of African languages and, according to their interview responses, tend to be disadvantaged educationally because they do not fit the profile of schools who think 'monolingually' (Stroupe et al., 2019) and make use of monolingual pedagogies in multilingual classrooms. Despite the school's restrictive monolingual proscriptions in the classrooms, during the study, these multilingual students showed the tenacity to transform monolingual classrooms and achieve better academic results in the subject area where translanguaging was permitted (Windschitl et al., 2018).

While the current language policing strategy in the country has followed the separationist ideology for a long period of time (Charamba, 2019b), classroom research has increasingly shown that multilingual learners have always resisted monolingual policy proscriptions in favour of fluid, versatile and mobile discursive resources to accomplish their classroom academic tasks (Miller et al., 2018). This resistance is full proof that all controlling devices over language use in the classroom are ineffective, futile and often counterproductive to language and content mastery (Gu, 2015; Makalela, 2018). Findings from the current study also prove that languages previously separated on the basis of cultural and linguistic differences can converge through fluid classroom interactions and enhance students' content mastery in Natural Sciences.

The current study proves that the scope for translanguaging in Viljoensdrift science classrooms is sufficiently wide to include the blending of several languages and multilingual spaces that cross within and between language clusters. It is within this complex and multi-layered language mixing as a social practice that translanguaging can be seen as indexical of the plural sense of being, *ubuntu,* which is shared across a wide spectrum

of speakers of indigenous African languages (Makalela, 2018) in the area. Hence beside academic gains, translanguaging in science also fosters a sense of belonging, oneness, and unity as evidenced by Student 6 and 11's responses:

Excerpt 11

I am proudly Sotho. All my classmates are Sotho. Our teachers are Sotho so when we are learning in our language I feel we are a family, we are one. Why must we speak to each other in a different language? Umuntu ngumuntu ngabantu [I am because you are, you are because I am].

Excerpt 12

If someone speaks to me or teaches me in my own language I feel honored, special and loved. This makes me want to please that person and in the process my marks get better. Us Sothos want to be associated with our roots. Using our language shows that we are one and youths will stick to their roots and be admired by other people.

The responses from these students show that beyond the affective, social, and cognitive advantages that come with translanguaging strategies for multilingual science learners (Garcia & Wei, 2014) the fluid use of languages can be harnessed as a methodology that is both linguistically and academically transformative (Rogers, 2014).

Effect of Natural Sciences learning materials written in students' home language

All students interviewed highlighted the positive effect of the English- Sotho Natural Sciences dictionary which they were given and used during the study. All participants attributed their improved academic performance to the dictionary. Below are excerpts from Students 4; 13; and 27 interviewed:

Excerpt 13

The Sotho dictionary helped me understand the work and get good marks. For me to pass I think I should be taught all [learning areas] in Sotho. Looking at the lessons and dictionary we had in Sotho I think the school must give us more materials written in Sotho.

Excerpt 14

Personally, I found the dictionary very useful. It translated words whose meanings I didn't know into Sotho. Words like excrete, organism, transpiration, [and] hibernate were translated and explained.

Excerpt 15

That dictionary was excellent. Some difficult words were translated there and some even explained. We are normally given those difficult words and have to google their meanings in English and it still doesn't help at all.

Students19 and 27 suggested that having learning materials for all learning areas written in their home language can make students understand the work better.

Excerpt 16

My feeling is that the department [Department of Education] must give us books in our mother tongue for all subjects. They help us understand the work better. This one [the dictionary used during the study] was very, very useful. If we also have worksheets for those difficult topics in all subjects written in Sotho, we will pass.

Excerpt 17

The lessons were good. I felt free to take part in class and group discussions because of the languages we were using. The teacher tried to make us understand by explaining some of the work in Sotho and gave us a dictionary he had prepared and this made it interesting. The dictionary was however small and was for one topic only. We need more [dictionaries] for all difficult subjects.

During the lessons, it was good to note that all participants were contributing during class and group discussions as highlighted by Student 27 (Excerpt 17). They were making use of their entire linguistic repertoire in contributing to the discussions, for example when students were discussing photosynthesis in their groups, the following was picked from one of the groups:

Excerpt 18

Student 9: I think plants li etsa lijo li sebelisa carbon dioxide.
Student 25: Yes but not carbon dioxide feela. Le tsona li sebelisa metsi.
Student 14: So it's just carbon dioxide and water? Ha ke utloisise.
Student 6: Li sebelisa carbon dioxide, metsi, chlorophyll le khanya ea letsatsi.
Student 2: I thought li sebelisa oxygen.
Multiple voices: Che, li lokolla oxygen.

The current research shows that plural orientation in the medium of learning enables multilingual Natural Sciences students to use all discursive resources at their disposal allowing them opportunities to perform well academically (Karlsson et al., 2018). In Excerpt 18, Student 9 starts the group discussion by stating that he thinks plants photosynthesise using carbon dioxide. To this Student 25 agrees and goes on to say but not carbon dioxide only. Plants also use water. Student 14 does not hide her surprise and asks if it's only carbon dioxide and water. Student 6 goes on to give the whole list stating that plants use carbon dioxide, water, chlorophyll, and sunlight. Student 2 who had been quiet all along opens up to say she thought plants use oxygen. To this multiple voices are heard disagreeing and stating that oxygen is actually released. This is another example of correct scientific facts being presented through translanguaging. This shows that scientific knowledge can be discussed in any language and the use of translanguaging does give multilingual students equal opportunities to partake in class discussions resulting in better comprehension of scientific concepts.

Considering the students' performance in the post-test the present study argues that translanguaging in a Natural Science classroom provides superior cognitive gains for multilingual students (Wei, 2018) worldwide through the simultaneous endorsement of literacies and languages by embracing all languages at the multilingual students' disposal (Miller et al., 2018). Students' responses during the interviews as well as their performance in the post-test show that language and learning are interdependent as language is the means of access to all study material (Stroupe et al., 2019). Cognitive skills in the Science classroom are developed by speaking, reading, and writing in a person's own language (Henderson & Ingram, 2018). Cummins (2008) states that where a language of instruction is concerned, one should accept, in principle, that the home language or primary language which developed within the context of social interaction and which is culture-bound is fundamental to the thinking, learning, and identity of an individual.

The present study reveals the benefits of translanguaging in the science classroom to include the following: ability by the students to engage fellow classmates through translanguaging and heteroglossia, endorsement of simultaneous literacies and languages (Sotho and English) to keep the pedagogic task moving, and improved academic performance (Rita, 2016). Translanguaging in the present study, and in other studies cited earlier on, presented opportunities for multilingual English learners to expand the means at their disposal to learn and demonstrate science understanding and skills and created spaces for them to further develop proficiency in English (Miller et al., 2018). For example in Excerpt 18, instead of having to demonstrate knowledge solely through the use of one language, translanguaging allowed science students to demonstrate what they knew through the use of more than one language (Windschitl et al., 2018). The students moved between English and Sotho in presenting their responses and during class discussions.

This research, like other previous research that proved the success of translanguaging practices in educational contexts, has provided opportunities for experimentation with indigenous African languages in South Africa on a wider scale focusing on all learning areas across the curriculum (Charamba, 2017, 2019b; Childs, 2016). The use of Tshivenda, isiXhosa, and English simultaneously in science courses at the University of Cape Town in South Africa has also proved effective in enhancing science literacy among university students (Madiba, 2014). Through translanguaging, therefore, African languages previously separated on the basis of cultural and linguistic differences can converge through fluid classroom interactions and enhance students' content mastery in Natural Sciences (Charamba, 2019a). Beyond the South African borders, schools that have experimented with translanguaging as a pedagogical strategy elsewhere in the world have also shown success within their programmes (Gu, 2015; Rita, 2016; Wei, 2018).

Discussion

The traditional teaching profession has always treated languages as separate and bounded entities (Garcia & Wei, 2014) in order to avoid contamination of one language by the other (Makalela, 2018). This monoglossic practice is imbued by the nation-building ideology that began to take shape during the European enlightenment period and that used separation as a strategy to control and form nation-states (Madiba, 2014). However, the current and previous research shows that educational pedagogies that favour monolingual bias as the target norm place some constraints on multilingual students' linguistic flexibility and academic achievement in Science (Charamba, 2019a; Karlsson et al., 2018).

The majority of the students in the study highlighted that the use of more than one language during the lessons and the provision of learning materials written in their home language made them understand the concepts better than in the typical monolingual interactions they are always subjected to (Charamba, 2019a, 2019b). Alternative pedagogical approaches for multilingual science classrooms have begun to recognise the simultaneous use of more than one language in classrooms for concept teaching and learning (Charamba, 2019a, 2019b) as this pedagogical approach has proved to be of academic benefit to the students (Windschitl et al., 2018).

This epistemological shift endowed the eighth-grade Natural Sciences students with better comprehension of concepts, articulated their reasoning and interactive prowess these being skills normally not accomplished in typical monolingual classrooms when

the language of instruction differs from the students' home language (Rita, 2016). Several studies on translanguaging have averred that the use of more than one language in the science classroom set up, especially when the students' home language is incorporated makes the students enjoy cognitive advantages when multilingualism is accommodated in the learning and teaching process (Charamba, 2019a; Charamba & Zano, 2019; Miller et al., 2018; Msimanga et al., 2017).

In this study the students' home language was brought into the learning process as a scaffold, collaborating with the English language and not against it. Students were allowed and encouraged to move between different linguistic structures and systems, including different modalities and going beyond them resulting in maximum apprehension and cognition of the science concepts learned. To this Student 26 said:

Excerpt 19

Well, I understand we have 11 official languages and it will be fair if I could be taught all subjects in Sotho and also have books and tests in that language. The government must allow us to learn in our mother tongue and get books written in that language and we will all pass with good marks.

In the present study, through translanguaging, the students' home languages were seen and taken as a resource in the abetment of acquisition of new scientific knowledge and not as a hindrance (Howe & Lisi, 2014; Krause & Prinsloo, 2016; Rogers, 2014; Wei, 2018). Translanguaging pedagogy moves away from monolingual teaching strategies towards a more integrated, less *boundaried* use of students' linguistic repertoire in teaching and learning (Henderson & Ingram, 2018), and already features strongly in the daily practices of these science students and teachers. The results from the post-test and interview responses show the positive effects of using learning resources written in the students' home language in the science classroom by reinforcing plural identities, bridging linguistic boundaries and increasing reasoning power through integrated multilingual academic practices (Karlsson et al., 2018; Stroupe et al., 2019).

The present study, like numerous before it, point to a 'multilingual turn' (Charamba, 2017, 2019a, 2019b; Henderson & Ingram, 2018; Karlsson et al., 2018; Msimanga et al., 2017; Probyn, 2015; Ramirez & Ross, 2019; Stroupe et al., 2019) that encompasses an epistemological shift from the acquiescence of monolingual paradigms to signal the focus on and need for multilingualism as the beginning point in understanding language practices, literacy, and academic achievement across the school curricula (Henderson & Ingram, 2018). Findings from the present study reveal that a heteroglossic orientation towards language systems and pedagogical practices has gained momentum in today's linguistically fluid academic spaces as it enhances students' academic achievement in Science (Jakobsson & Davidsson, 2012; Kamberelis & Wehunt, 2012).

Contrary to the current school set- up in South Africa, multilingualism in education does not expect students to cast off their language and culture as they cross the school threshold, nor to live and act as if school and home represent two totally separate and different cultures which have to be kept firmly wide apart. Instead, the multilingual curriculum reflects many elements of the life which students live outside school (Childs, 2016). While Garcia construes the complexity of multilingual education through a recurring analogy of the banyan tree, a South African scholar, Makalela views African multilingualism through the 'Sankofa lens', a notion used by the Ghanaians which means 'going back

to fetch' (Makalela, 2018). The notion views the past and the present as being interlocked through the search for consistency of practices and applications in the present context and suggests that it is not a taboo to go back and fetch that which is at risk of being left behind (Msimanga et al., 2017).

Sankofa attempts to reconstruct African multilingualism by reflecting on pre-colonial social entities in a bid to look for practical models and solutions applicable to the Southern African context (Makalela, 2018). The whole idea centres on looking back at pre-colonial ways of communication and revert to such practices. The historical ways of communication among the African people were punctuated by multilingualism. Through the *Sankofa* lens, the present study suggests that the South African education system should go back to fetch (1) old systems of communication and use them in the classroom; (2) those students who are at the risk of being left behind academically due to linguistic barriers created by monolingual bias prevalent in today's science classrooms across the country as evidenced by the students' academic performance in the pre-test; and (3) those minority languages at the risk of extinction if not used regularly (Charamba, 2019a).

Translanguaging in the science classroom, therefore addresses and redresses the 'melting pot' theory of past years which resulted in the near-death of local languages (Howe & Lisi, 2014) while at the same time affording students a chance to learn science in their mother tongue or preferred language, alongside the language of instruction (Rita, 2016). Translanguaging in the Science classroom does not replace the language of instruction but it is a notion where the languages of input and output are alternated (Henderson & Ingram, 2018). The idea is to allow science students to learn through various languages. This means that the students use both their first and second languages in meaning-making activities and in student-to-student negotiations about the significance of specific words in order to facilitate their understanding of scientific concepts (Windschitl et al., 2018).

The UN's declaration of 21 February as International Mother Language Day is an opportune time to examine the pedagogical, policy and practice of the promotion of the language of education in South Africa. To foster sustainable development, students must have access to education in their mother tongue and in other languages. It is through the mastery of the first language or mother tongue that the basic skills of reading, writing and numeracy are acquired (UNESCO, 2018). In light of the above, it is opportune that the 2018 theme for International Mother Language Day is '*Linguistic Diversity and Multilingualism Count for Sustainable Development*' (UNESCO, 2018).

As pointed out elsewhere in this article, most science students and teachers in South Africa use their mother tongue in the early years of primary education, which enables them to negotiate language and conceptual competences with relative ease. The switch in the third or fourth grade to learning and teaching in another language snatches the blanket of the familiar language away (Childs, 2016). Translanguaging could provide a means of extending the use of the mother tongue or main language purposefully and systematically into the higher academic grades (Henderson & Ingram, 2018). The students' mother tongue can thus be used as a bridge to the required school's language of instruction. The goal would thus be one of multilingualism rather than foregrounding competence in the language of instruction.

Conclusion

A fundamental challenge in the present day multilingual science class is to meet the needs of students from linguistically sundry backgrounds who possess finite proficiency of the English language, which happens to be the language of instruction in more than 90% of the schools in South Africa (Statistics SA, 2017). The present study joins the current body of research which proposes the use of a language different from the students' home language to be the prime cause for students' academic underachievement in science (Childs, 2016; Miller et al., 2018; Msimanga et al., 2017; Ramirez & Ross, 2019), suggesting that amplified cognitive and metacognitive skills are achieved when translanguaging techniques are applied in multilingual classrooms (Choi et al., 2019; Cunningham, 2019; Gee, 2015; Gu, 2015).

There has been a tendency in most countries of developing educational policies on the simulation that tutelage is identical for everyone in the science classroom (Probyn, 2015), where students get taught and assessed in the same way disregarding the fact that the process of education can be a very different (Madiba, 2014) experience depending on one's socioeconomic, socio-cultural and linguistic background (Msimanga et al., 2017). This monolingual bias has proven, according to this and other research carried out across the globe, to contribute to the academic underachievement of most science students. Translanguaging, therefore, offers an alternative educational pedagogy for the multilingual science student since it acknowledges linguistic diversity which in turn facilitates education for sustainable development.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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