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Pushing linguistic boundaries: translanguaging in a bilingual Science and Technology classroom

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ABSTRACT

In spite of the fact that increased transnational flows of people have altered the social, cultural, and linguistic landscape, education in Zimbabwe still follows a monolingual trajectory. The use of a language of instruction different from the students' home language has been identified as the major factor in students' academic underachievement. This article reports on a study that sought to investigate the role played by language in the academic performance of 40 fourth-grade Science and Technology students at a primary school in Bikita district, Zimbabwe. In this mixed-methods study, participants were randomly assigned to either the control or experimental group using Research Randomiser. The experimental group had translanguaging-informed intervention while the control group followed the traditional monolingual approach. A paired t-test revealed a statistically significant difference in the academic achievement of the two research groups in the post-test suggesting the efficacy of translanguaging in the classroom. The present research findings are in line with previous research which affirm the academic benefits of doing away with 'named languages' through the use of students' linguistic repertoire in the classroom.

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Science and Technology education; home language; multilingualism; translanguaging; bilingualism

Background

Considering the academic performance of seventh-grade students in Zimbabwe, the examination results released by the Zimbabwe Examinations Council (ZIMSEC) in the past five years do not present hope for having a scientific and technological literate nation in the near future. The overall pass rate in the seventh-grade examination for the years 2015–2019 was 41,6%; 42,9%; 44, 73%; 52,08% and 46,9% respectively (Zimbabwe School Examinations Council 2019). In Zimbabwe, at the end of the seventh-grade students take a national examination in English, Mathematics, Shona or Ndebele and the General Paper. The General Paper examination covers the Social Sciences, Science and Technology, and Religious Education. The seventh-grade examination is not a terminal examination like the Ordinary ('O') and Advanced ('A') level examinations and a candidate's performance in each learning area is graded on a scale that stretches from Grade 1 (the best) to Grade 9 (the least).

ZIMSEC is a parastatal organisation under the Ministry of Education, Sports and Culture of the Republic of Zimbabwe, and is responsible for the administration of public examinations in Zimbabwean primary and secondary schools. A five-year analysis of the results for the four learning areas (English, Mathematics, Shona or Ndebele and the General Paper) in the seventh-grade examination suggests that students underperform in the General Paper particularly in the Science and Technology

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section of the paper (Charamba 2019a; Charamba et al. 2019). The analysis suggests the language of instruction is the major barrier in the students' academic performance. Bantu-speaking ethnic groups account for 98% of Zimbabwe's population. The largest group is the Shona, comprising 70%, followed by the Ndebele at 20% while white Zimbabweans account for less than 1% of the country's population and most are of British origin. The rest are other Bantu ethnic groups such as the Kalanga, Khoisan, Nambya, and Venda (United Nations, Department of Economic and Social Affairs, Population Division 2019).

This recent demographic data not only has implications for the nature and timing of instructional practices within classrooms but also for the types of assessment strategies implemented across all types of accountability purposes in the Zimbabwean maths classroom. Although the Constitution of Zimbabwe recognises 16 official languages, namely Chewa, Chibarwe, English, Kalanga, Khoisan, Nambya, Ndau, Ndebele, Shangani, Shona, Zimbabwe Sign language, Sotho, Tonga, Tswana, Venda, and Xhosa (Charamba 2019a), these are used for instructional purposes in the first and second grades only. In these first two grades, students' linguistic repertoire is used for instructional purposes across the curriculum for content delivery, asking/answering questions, oral collaborative and class discussions, and for writing class activities and assessments. From the third-grade upwards classroom instruction and assessment still hinges on the unspoken and unscripted policy of monolingualism with the language of instruction being English and this creates pedagogical challenges to the teaching and learning of science (Babaci-Wilhite 2016).

In Zimbabwe, although English has become the Lingua franca like in most parts of the world (Gao and Wei Ren 2019), it is the home language for less than 1% of the country's population (United Nations, Department of Economic and Social Affairs, Population Division 2019) and its sole use in Zimbabwean classrooms classroom has been attributed to students' underperformance as 99% of the country's population is not native speakers of English. This is in conformity with a body of recent research in science education which suggests that low proficiency in the language of instruction is the major cause of low academic performance amongst science students whose home language is different from the language of instruction (García and Lin 2018; Li and Lin 2019). The main reason being that as students get into higher grades, both the content and language of science become more difficult (Lems and Stegemoller 2014). The present study, an extension of studies by the author that focuses on translanguaging in science classrooms (Charamba 2017; Charamba 2019a, 2019b; Charamba & Zano 2019; Charamba et al. 2019), focuses on a fourth-grade Science and Technology (S & T) class in Bikita district, Zimbabwe whose home language is Shona and are taught through the English language.

Theoretical understandings of classroom translanguaging

In their analysis of the 2015 Trends in International Mathematics and Science Study (TIMSS) results for grades five and nine, Reddy et al. (2016) identified the difference home language and the language of instruction as the major cause of the participants' underachievement in the academic assessments. TIMSS is an assessment of the mathematics and science knowledge of fourth and eighth-grade students from selected countries around the world. In the TIMSS assessment top academic achievers came mostly from countries that emphasis instruction in the home language. For example from South Korea through Japan and China, to Russia, all of Europe and North America, schools' language of instruction is children's home language (Wolff 2018).

In these countries, students are taught global languages such as French and English in preparation for global communication later in life. Whilst in school, these global languages are used alongside students' home language in the classroom, enabling students to fully grasp the complexities and applications of their home languages and a foreign language (Cummins 2008; Wolff 2018). The difficulty with the scientific language does not result from vocabulary alone, but from sentence structures, references within and between sentences, and larger discourse patterns which have to be unpacked in a language understood by the student (Lems and Stegemoller 2014).

The natural use of different languages together by multilingual people for communication purposes has been in practice in most parts of the world since time immemorial. But as a focus of research, this concept emerged in the 1980s when Cen Williams and associates were exploring effective strategies for students to use two languages in the same lesson. They coined the term 'trawsieithu' (Li 2018) to describe the process in which students would read or hear in one language (for example English) and then write or speak about what they would have read or heard in another (for example Shona, or vice versa). The term was then translated into English as 'translanguaging' by Colin Baker (see Lewis, Jones, and Baker 2012). This marked a paradigm shift, moving away from traditional linguistic terms such as codeswitching, and codemixing, calling into question the existence of 'languages' as identifiable, distinct systems (Makoni 2018).

The concept of translanguaging views language as an ongoing process that only exists as languaging (Sánchez, García, and Solorza 2018) which shapes and is shaped by people as they interact in respective contexts. Translanguaging challenges Cummins's (2008) 'two solitudes' approach to bilingualism, in which different languages were kept separate and is described as the ability of multilingual speakers to shuttle between languages, treating the diverse languages that form their repertoire as an integrated system (García and Lin 2018). According to Li (2018), the linguistic resources that are relevant in the education space are those brought and shared by the students through fluid linguistic discourses. In the classroom, translanguaging draws on the languages brought to class by the students and it is the teacher's social responsibility to welcome these languages and encourage the students to use them in the classroom (Lin 2019).

Translanguaging is a practice that involves the dynamic and functionally integrated use of different languages and language varieties, but more importantly, a process of knowledge construction that goes beyond languages (Gao and Wei Ren 2019; Li and Lin 2019). For academic reading in science students can use translanguaging to practice academic scientific discourse structures through sentences frames or partially completed sentences (Lems and Stegemoller 2014). Translanguaging pedagogy disrupts the hierarchy of languages in the classroom, transforms both teachers' and students' attitudes towards their diverse meaning-making resources, thereby enabling students to fully participate in knowledge co-making (García and Lin 2018). In their definition, Hua, Otsuji, and Alastair Pennycook (2017) posit that translanguaging views language as a multilingual, multimodal, and multisensory sense- and meaning-making resource.

Previous research

The process of translanguaging involves an individual using their full linguistic repertoire including all the linguistic varieties such as registers, dialects, styles, and accents. The acknowledgment and acceptance of a fluid linguistic discourse in the classroom creates a space for maximum participation in the co-construction of knowledge by the students and teachers (Li 2018). A qualitative study by Zhang et al. (2020) of the practice of medium of instruction choice in eight Chinese as Foreign Language classrooms across five universities in China suggests that translanguaging was commonly used by teachers resulting in improved student academic performance, participation, and motivation during lessons. In Singapore, Vaish (2019) observed linguistic practices among multilingual students in seven classes and concluded that translanguaging can work in a classroom culture where the overall goal is meaning-making and both the teacher and the students participate in a more democratic sharing of talk time.

In their study in the United States of America, Meyerhöffer and Dreesmann (2019) also suggest that translanguaging pedagogy allows students to move between different languages in the meaning-making process begetting improved academic performance in the science classroom. In South Africa, Probyn (2019) notes that there has been a corresponding interest and research in translanguaging in South African classrooms, some of which reports on spontaneous language use in classrooms (for example Krause and Prinsloo 2016; McKinney 2017; Probyn 2015) while some documents interventions that have adopted planned heteroglossic pedagogies that engage with students' full linguistic

repertoires (for example Fortuin 2017; Guzula, McKinney, and Tyler 2016; Madiba 2014; McKinney and Tyler 2019; Msimanga, Denley, and Gumede 2017).

In another study, Infante and Licona (2018) show how multilingualism can be valuable in framing and supporting epistemological access across the school curriculum in Mankato. The findings of the study show better academic performance among students who were allowed to use multiple languages during educational activities. The researchers advocate for the acceptance of multilingualism as a teaching and learning resource. However, little if any, research has been carried out to explore the efficacy of translanguaging in Zimbabwean Science and Technology classrooms, hence the aim of the present study.

Context of study

In Zimbabwe, primary school education begins in grade R hence to be in the fourth-grade a student will be in their fifth year of formal schooling and be about 11 years old. The Science and Technology (S&T) curriculum is a five-year primary school course, offered from the third to seventh-grade. The learning area provides students with opportunities for cognitive and practical experiences that help them understand, interpret, and offer practical and meaningful scientific solutions to their natural world (Ministry of Primary and Secondary Education 2015).

The learning area, Science and Technology, is allocated 150 minutes a week in the primary school timetable and covers topics such as *Energy and Fuels; Electricity and Electronics; Forces and Magnets; Design and Technology; and Water* (Ministry of Primary and Secondary Education 2015). In Zimbabwe, students are taught through their home language alongside English from grade R to the second-grade. The language of instruction from the third-grade upwards is English except during indigenous language lessons (Charamba 2019a).

Materials and method

The study sought to explore the effect of language and the efficacy of translanguaging pedagogy in a fourth-grade Science and Technology Zimbabwean class.

Research questions

The research questions for the study were:

a What is the role of language in the teaching/learning of fourth-grade Science and Technology?
b How can translanguaging be used in the tutelage of Science and Technology to fourth-grade students?

Null hypothesis

Language does not affect the academic performance of S & T students.

Setting

The study was conducted at a rural primary school in Bikita district, Masvingo province. The province lies in the southeast of Zimbabwe and has a population of about 1.485 million (Zimbabwe National Statistics Agency 2017) spread across seven districts. The province, established as Victoria province by the British South Africa Company, boasts of The Great Zimbabwe national monuments, a world heritage site located in the northern part of the province (Zimbabwe National Statistics Agency 2017). Masvingo province is dominated by the Karanga tribe, a sub-group of the Shona

speaking tribes (Charamba 2019a). The mountainous Bikita district, situated about 80 kilometres east of Masvingo city, borders with Gutu, Zaka, Chipinge, Buhera, and Mwenezi districts. The district does not have any industry, save for the lithium mine reputed to have the largest reserve of petalite in the world (Zimbabwe National Statistics Agency 2017). The majority of parents in the district are in the low-income bracket that relies on tilling the land and practicing animal husbandry for survival, the reason the school understudy is fully funded by the Ministry of Primary and Secondary Education (Charamba 2019a).

According to students' profiles obtained at the school, all students enrolled in the school are natives whose home language is Shona. Considering the socioeconomic status of most parents in Bikita district, most children in the area receive their primary and secondary education at one of the nearby public schools where all the teachers are also natives who share the same home language as the students (Charamba 2019a). The sample for the present study comprised of 40 fourth-grade students. Consent for their participation in the study was sought from their parents. The participants were informed that participating in the study was not compulsory and were also informed that if they chose to take part in the study they were free to withdraw from the study at any time without any fear of punishment. To protect their identities, participants were randomly assigned pseudonyms and were referred to using these throughout the study. The participating students were then randomly assigned to either the control or experimental group using Research Randomiser. Each group had 20 participants.

Data collection and analysis

A mixed-method approach was used to generate data from a sample of 40 fourth-grade students at a primary school in Bikita, Zimbabwe on the role of language in the learning and teaching of Science and Technology. The present study made use of a mixed-method approach as both quantitative and qualitative types of research have weaknesses and either of them wouldn't have adequately answered the research questions. Quantitative research is shaky in understanding the context in which research data is collected. Qualitative research, on the other hand, may include biases and does not lend itself to statistical analysis and generalisation (Creswell 2014). The solution, therefore, lies in using mixed method strategies, which appear to offset these weaknesses by allowing for both exploration and analysis in the same study through the collection of both quantitative and qualitative data in this study (Bryman 2015).

In the present study, while quantitative data included closed-end information that underwent statistical analysis, qualitative data were more subjective and open-ended allowing for the 'voice' of the fourth-grade S & T students and their teacher to be heard (McMillan and Schumacher 2010). In collecting qualitative data two data collectors sat at the corners of the classroom and recorded two-30 minute lessons per week from each of the classes using video recorders for 6 weeks. To support the qualitative data collected through videos and observations, interviews were also conducted. The study made use of video recording to visualise and understand how these students' authentic language use may affect their participation and comprehension of concepts in S & T (Lemke 2012). The researcher formally interviewed the teacher, Ms. Maidei (not her real name) at the beginning and end of the study to better understand her role in shaping the linguistic topography in her classroom. The researcher also interviewed her informally at several points throughout the study using video-elicitation techniques (Creswell 2014) by showing her selected video footages where students in the experimental group were actively translanguaging.

The researcher also interviewed students who had performed better in the post-test than the pre-test as well as some who had engaged in translingual practices during the study. Their responses were used to triangulate the researcher's interpretations of the data collected. To ensure the validity and trustworthiness of the research, direct quotes from the participants are used. Because of their proficiency in the English language, all students chose to be interviewed in Shona. The responses were translated by the researcher with the teacher's assistance and they are labelled RT (Researcher

Translations) in this article. The analysis of qualitative data for this study involved a combination of both inductive and deductive analysis (Bryman 2015) using Glăser and Laudel's (2010) model. Deductive codes emanated from the literature reviewed and included: translanguaging, meaning-making, and epistemological access whereas inductive codes resulted from an analysis of field notes, interview transcripts, and video footage of classroom interactions (McMillan and Schumacher 2010).

In this study quantitative data were collected from 2 written tests; the pre- and post-tests. The pre- and post-tests were developed by the researcher in consultation with the Science and Technology teacher at the school understudy. The tests were developed according to the research's aims. The tests were then sent to the Ministry of Education district offices for reliability and validity checks. During the pilot study, two of the questions were found to be a grade higher than that of the intended sample and the researcher adjusted the questions accordingly.

Quantitative data were analysed using SPSS statistical analysis. In analysing the participants' academic performance during the study, the researcher calculated and compared the respective means, standard deviations, *p*-values, variances, significant levels, confidence intervals, and degrees of freedom for both groups in the assessments written (McMillan and Schumacher 2010). The research procedure can be summed up as follows (Table 1).

Intervention Procedure

Zimbabwe, like most African countries, has been largely excluded from the global pedagogical transformation in STEM, where the emphasis is on the importance of language choice and the development of English Language Learners in the Science and Technology classrooms (Babaci-Wilhite 2016). During the intervention phase, the teacher taught both groups at different times in the presence of the researcher. The researcher and Head of Department assured quality teaching of both groups by the teacher. Both groups were taught the same concepts for 30 minutes a week over 6 weeks. The lessons were on the topic *Water,* covering sub-topics such as sources of protected and unprotected water, states of water, and uses of water.

The control group was taught through the English language. The class and collaborative group discussions were also in the English language. The experimental group, on the other hand, was allowed to use their linguistic repertoire during class discussions, collaborative discussions, and in giving written responses for the post-test. During the intervention phase, Ms. Maidei allowed and encouraged the students in the experimental group to use their repertoire to ask questions, respond to questions, during group discussions, or when seeking clarity of concepts from the teacher or their classmates. During the study, in some cases where the experimental group seemed not to have understood the concept she was teaching, the teacher took the initiative to translanguage, for example when she was highlighting the dangers associated with consumption of water from unprotected sources and said:

Excerpt 1

Ms. Maidei:	We all remember sources of unprotected water, right? *Zviya takati nzvimbo dzisina kudzivirirwa dzatingawana mvura ndedzipi?* (State examples of unprotected water sources).
Netsai:	Rivers
Chipo:	*Matsime nemakuvi* (uncovered wells and unprotected cisterns)
Njeke:	*Mhango dzemiti* (cavities of trees)

Table 1. Summary of data collection processes.

Stage	Activity
1	Pre-testing all participants
2	Intervention: both groups and interviews
3	Post-testing: both groups
4	Data analysis and interviews

Tendai:	Seas and oceans
Ms Maidei:	Correct all those sources *hadzina kudzivirirwa*. *Saka kana tikanwa mvura inobva munzvimbo idzi chii chinoitika kwatiri?* What do you think will happen to us if we drink water from such sources? *Taurai tinzwe* (Let's hear your thoughts).
Anesu:	*Tinobata zvirwere* (We might get diseases).
Ms Maidei:	*Sezvipi?* (Like which diseases?)
Tinashe:	*Manyoka* (dysentery)
Rudo:	Cholera
Tawanda:	*Chirwereuchapa*
Ms Maidei:	So what should we do *kana tisina mvura inobva munzvimbo dzakadzivirirwa*? Let's say *tine nzvimbo idzi chete, todii kuti tishandise mvura iyi zvakanaka*? (How can we make sure the water from these unprotected sources is safe to use?).
Tambu:	*Tinogona kuvidza mvura yacho* for 10 minutes
Anopa:	*Ku* clinic *vakati tiongona kuisa matombo pamoto* for 30 minutes then *tozomaisa mumvura.* Germs will die (At the clinic they advised us to heat stones for about 30 minutes and then dip them into the water from an unprotected source).
Tapiwa:	*Isu takapiwa ma* tablets ku clinic *pakamboita ma* floods *paya* (During the floods, we were given purifying tablets).
Ms. Maidei:	All your answers are correct. In the next lesson, we will discuss how we can make a water filter.

In this excerpt (Excerpt 1), Ms. Maidei starts by asking the students if they still recall sources of unprotected water. In line 3, one of the students, Netsai gives her answer in the English language 'rivers'. In line 4, Chipo joins the discussion by responding in Shona that other unprotected sources of water are *matsime nemakuvi*, meaning uncovered wells and unprotected cisterns found on the ground or rocky surfaces, especially on mountains. *Makuvi* are a common feature in Bikita as the district is punctuated by countless mountains and hills. Njeke gives his answer in line 5 as *mhango dzemiti,* meaning water found in cavities of trees. The students in this part of the excerpt were able to give their answers while translanguaging. The use of more than one language in responding to the question did not contaminate the scientific correctness of the answers. All answers given by the students are correct, irrespective of the language used.

In Excerpt 1, line 7 the teacher agrees with her students' responses and goes on to ask what they think would happen if they were to drink water from these unprotected sources. To this Anesu responds in Shona (line 10), *tinobata zvirwere* meaning we will get sick. The teacher probes the class into citing examples of such diseases. In line 12 Tinashe gives *manyoka* (dysentery) as an example. Rudo contributes to the class discussion by giving her answer in English, 'cholera' (Line 13). Tawanda, in line 14, gives a term used in most parts of the country to refer to typhoid, *chirwereuchapa,* loosely translated as 'disease caused by poor hygiene'. The traditional belief was that people who had poor hygienic standards got infected. In line 15 the teacher agrees with her students before pushing them further by asking them for solutions to the problem if there are no protected sources to provide them with safe drinking water. Tambu responds in line 17 using translanguaging to suggest that water from unprotected sources can be boiled for a minimum of 10 minutes.

In line 18 Anopa tells the class what they were told at an awareness campaign at the local clinic. He says '*vakati tinongona kuisa matombo pamoto* for 30 minutes then *tozomaisa mumvura* (Excerpt 1 line 18), meaning another alternative is to heat stones for 30 minutes and then put the hot stones in the water. This kills all germs. Anopa's method has been widely used especially in cases where one does not have a suitable container to place onto the fire to boil their water. In line 20 Tapiwa, a new student in the school, tells the class that they had been given water purifying tablets when their area experienced floods. He was referring to floods caused by Tropical Cyclone Idai that destroyed infrastructure and killed thousands of people in Mozambique, Zimbabwe, and Malawi in the year 2019 (UN Office for the Coordination of Humanitarian Affairs 2019).

Participants in both groups (control and experimental) were given academic activities to do in groups. The control group discussed and answered questions in the English language only while the experimental group used their linguistic repertoire. After the intervention, students in both groups wrote the same post-test under the same conditions.

Results

The effect of second language in the academic performance of Science and Technology fourth-grade students

During the interviews most students indicated that they did not do well in the pre- test due to their low proficiency in English. This affected them during lessons as well as during the test as they could not fully understand the concepts taught to them in class as well as the questions. In her response explaining the difference in her performance in the two tests, Ruvarashe (Interview 13 October 2019), one of the students who showed considerable improvement in the post-test said:

> *My command of English is not good at all. When the teacher is teaching in English, I don't understand most of things she says. But when she uses both English and Shona simultaneously, that is different. I grasp the concepts and won't forget what I have been taught.*

To this and similar responses, Ms. Maidei (Interview, 13 October 2019) said most of 'the students participate and perform well when they use their linguistic repertoire during instruction. Remember they were born and grew up here in the rural areas where English is considered nothing but the language of the classroom. They only speak, read, and hear the language in the classroom. Once outside the only language they use is Shona'.

The pre-test carried 20 marks and all participants wrote it under the same conditions. In this test, 3 students from each group scored 50% or better. The control group had a mean of 4.0 compared to 3.88 for the experimental group. The standard deviation for the control group was 3.2 while the experimental group had 3.0. The calculated p-value was 0.45. Given that the p-value > 0.05, we, therefore, fail to reject the null hypothesis (Bryman 2015) in as far as the pre-test is concerned. Basing on the statistics for the pre-test, there was no significant difference in the academic performance of the two groups (Creswell 2014). These results underscore the pivotal role language plays in the teaching and learning of Science and Technology and is in line with previous research which suggests that there is a close relationship between the language of instruction and students' academic performance (see for example McKinney and Tyler 2019; Menken and Sánchez 2019; Msimanga, Denley, and Gumede 2017).

The same position was also highlighted by Rudo (Interview, 13 October 2019) when she said:

> I only speak English in class. At home we speak Shona and my parents do not understand English so we even listen to Shona programs on the radio so learning Science and Technology in English makes it worse. Speaking and writing using both English and Shona makes a huge difference in my education, I understand everything I was taught and get high marks. [RT]

This suggests that rejecting multilingual students' use of their linguistic repertoire implies that they will be expected to perform well in the classroom while using a limited part of their language resources for meaning-making (Yuvayapan 2019). Vygotsky (1978) views students as social actors whose cognitive development is dependent upon language. Through social interactions, multilingual students construe relations between their everyday languaging and school languaging which in turn helps in concept comprehension and assimilation (García and Sánchez 2018). Using their linguistic repertoire helps the students during instruction since the language found in the classroom is more abstract and complex (Karlsson et.al, 2018). This answers Marita's concerns she raised (Interview, 13 October 2019):

> My teacher says my English is good and during school events I represent my class in narrating poems in English language but I do not understand why I get low marks in English language and Science and Technology. [RT]

In another study, Caruso (2018) analysed linguistic practices in a Language and Communication policies course at the University of Algarve, in Portugal. The student population was half local students and half Erasmus. The lecturer allowed the students to use their linguistic repertoires in all academic activities including when writing to achieve a collective comprehension of the content,

which in most cases was in English. Caruso reports on the benefits of translanguaging which led to the co-construction of knowledge in a co-learning environment and an improvement in the students' acquisition of the English language. When the same students were asked to take a structured multilingual final assessment task, the results show an improvement in the academic performance of the students due to the creation of spaces for translingual practices.

The students in the study are expected to learn Science and Technology through English without being equipped with the English language skills necessary to cope with the demands of the learning area and this can result in students underperforming from an early age, as seen in their performance in the pre-test. Research suggests that it takes five to seven years or more for a student to acquire a second language to a level sufficient to cope with the full curriculum (Lin 2019; Probyn 2019).

Academic benefits of using students' linguistic repertoire in the Science and Technology classroom

According to the interview responses and post-test scores, the use of translanguaging as a pedagogical tool offers multilingual students increased possibilities for content learning in the classroom, as pointed out by Daniel (Interview, 20 October 2019):

> Being able to use my linguistic repertoire helps a lot. It made me enjoy the lessons. I was really motivated and I think that is why I performed so well in the second test (post-test). [RT]

During the study, classroom observations revealed translanguaging can be a strategic tool for teaching and learning (Charamba 2019b). Students in the experimental group frequently used their linguistic repertoire as they negotiated meaning and shared ideas in the science classroom. For example, during an experiment to show the changes ice undergoes when heated, excited conversations could be heard as participants followed the proceedings. As the ice turned into a liquid, one of the participants, Brian, excitedly pointed shouting '*hona!* Ice *iya yava mvura wena'* (Look! the ice has turned into water!). Some students who were near him joined in describing what was happening (see Excerpt 2):

Excerpt 2

Chipo:	*Ehe yava* liquid *manje* (Yes, it's now in liquid state).
Tendai:	*Inyaya yemoto*. Fire is hot (It's because of the fire).
Tinashe:	*Chiutsi chava kubuda, hona* (Look, it's producing steam).

In Excerpt 2, Chipo agrees with Brian that the ice has turned into liquid. Tendai joins the conversation by stating the reason for the change in state. She states the change is due to fire because 'fire is hot' (Excerpt 2, Line 2). Tinashe draws the group's attention to a new development by informing them the liquid is now turning to steam (Excerpt 2, Line 3). At this point, the teacher calls the class to order and asks them to describe what they saw and give the possible reasons. Part of the conversation is presented in Excerpt 3:

Excerpt 3

Rudo:	Ice *yachinja kuva mvura nekuda kwe* heat *yabva kumoto* (Ice turned to liquid because of heat from the fire).
Tawanda:	Liquid *iya yazochinja kuita* gas *payanyanya kupiswa nemoto* (When the heat increased, the liquid turned into gas).
Anopa:	Ice *yaita* liquid *ikazoita* gas (Ice turned into liquid then gas).
Ms. Maidei:	Correct. The ice changed to a liquid and then steam. All this was because of heat. *Saka kana tiine ice tikaiisa pamoto inoita mvura. Ikaramba iripo yozoita steam.*
Tambu:	Teacher, *kumba ndakaona kuti kana* steam *ikaenda pamuvharo wepoto inochinja kuita* liquid *zvekare* (At home I also noticed that if steam gets into contact with the lid of a pot the steam turns back into liquid).
Ms. Maidei:	That's true. If steam gets into contact with a cool surface *inochinja kuita* liquid.
Anesu:	*Saka liquid inozoita* ice *sei*? (How does a liquid turn into ice?).
Tapiwa:	*Kana mvura ikaiswa mu* fridge *inoita* ice (If water is put in a fridge it turns to ice).

In Excerpt 3, Rudo starts by stating that ice turned into a liquid because of heat from the fire. Her classmate, Tawanda, adds that the liquid then turned into gas. He gives a possible reason for this as 'intense heat caused that' (Excerpt 3, Line 2). Anopa joins the discussion by giving a summary of the changes they saw by highlighting that 'ice turned into a liquid then gas as heat intensified' (Excerpt 3, Line 3). In Line 4, the teacher consolidates the students' responses affirming the change in states was indeed caused by heat.

Tambu chips in with an observation she has made. She says at home she noticed that if steam comes into conduct with a cool surface it turns back to liquid. Tambu's contribution is evidence that translanguaging practices and pedagogies within multilingual S & T classrooms provide students with increased opportunities for meaning-making and offers them a platform to express their views and experiences. In Line 9 of the same excerpt, Anesu asks how a liquid turns to ice. His question is answered by Tapiwa who states that when liquid water is put in a refrigerator it turns into ice. In explaining the current excerpt (Excerpt 3), Ms. Maidei says since she allowed students 'to use their home language together with English, there has been a tremendous improvement in their performance. Some who used to be quiet are now actively contributing during class discussions' (Interview, 20 October 2019).

The three excerpts show how translanguaging supported experimental group students in sharing the entirety of their ideas during the lessons and in answering the post-test. This happened well even if these S & T students did not yet have full proficiency in the language of instruction as no linguistic boundaries existed. The control group was limited to the use of only one language and 'using English only is difficult. I don't understand most of the words the teacher says. From grade 1 to grade 3 we were using Shona and English' (Pamela, Interview 20 October 2019).

In defining translanguaging, Grosjean (2019) uses an analogy on hurdles, where two athletic skills, high jump and sprinting are involved. Hurdlers use these skills together with other physiological processes as an integrated whole to excel in their sport just in the same way these multilingual S & T students were using their linguistic skills for meaning-making and effective communication. The null hypothesis for the study was 'language does not affect the academic performance of S & T students'. After the pre-test, the experimental group was then given intervention (translanguaging-informed) while the control group continued using the language of instruction only during the lessons. Presented in Table 2 is a summary of the academic performance of the two groups in the post-test.

The assessment activity carried 20 marks. While all students in the experimental group scored at least 50% in the activity, only 10% in the control group managed to reach the 50% mark. The calculated Cohen's d effect size was 2.808. Effect size is a standardised, scale-free measure of the relative size of the effect of an intervention. The effect size for the present study suggests the intervention (use of multiple languages) had a huge impact on the experimental group's academic performance (McMillan and Schumacher 2010). The calculated p-value was 0.000018 and the significance level 100%. Basing on the effect size which is greater than 0.8, there was a large difference between the two groups under comparison. This is supported by the p-value ($p < 0.05$), also indicating strong evidence of the difference in academic performance between the two groups. Considering this statistical analysis, the null hypothesis is rejected as there is strong evidence (Bryman 2015) suggesting the effect of the intervention, as seen in the difference in the academic performance of the control and experimental groups.

There was also a huge difference between the two groups' standard deviations. The scores for the experimental group, as evidenced by a smaller standard deviation (SD = 2.013), were distributed

Table 2. Summary of participants' academic performance in the pre- and post-tests.

	Pre-test			Post-test		
	Mean	SD	p-value	Mean	SD	p-value
Control group	4.0	3.2	0.45	4.9	3.43	0.000018
Experimental group	3.88	3.0		12.8	2.015	

around the mean ($\bar{x}$ = 12.80). The control group had a smaller mean ($\bar{x}$ = 4.90) and a larger standard deviation (SD = 3.43). The standard deviation for the control group indicates that the scores were spread out over a wider range. While the standard deviation for the experimental group suggests a much more homogenous academic performance for the group (McMillan and Schumacher 2010), the value for the control group suggests an opposite story.

The control group had a variance of 11.78 while that for the experimental group was 4.06. The results show there was a statistically significant difference in the performance of the two groups (Creswell 2014). During an interview on the 20 October 2019, Ms. Maidei suggested '*the difference in performance could be attributed to the experimental group's use of their entire linguistic repertoire (intervention) during the lessons and in answering the questions*' (see Excerpt 4 which is an extract from a script for one participant in the experimental group):

Excerpt 4:

Question

Write four unprotected sources of water

Nyora nzvimbo ina dzisina kudzivirirwa matingawana mvura

Participant's answer

Dams, nzizi, ma well asina kuvakirwa, ponds.

The participant wrote 2 answers in the English language (dams, ponds), one in Shona (nzizi which means rivers), and one in both languages (ma well *asina kuvakirwa* which means unprotected wells). In the assessment activity, such answers were marked correct as the use of a language other than English did not change the scientific correctness of the answers. Translingual practices were common in the experimental group during class and collaborative group discussions. Ms. Maidei explains that 'using both languages even for writing has resulted in students completing the activities and getting most of the answers correct. The time they take is also shorter than when I used to adhere to the one language policy' (Interview, 27 October 2019).

Very recently, some test developers and researchers have begun to incorporate *translanguaged* elements, primarily for content assessments (Baker and Hope 2019). Dendrinos (2013) reports on mediated language environments in state assessments in Greece, where source texts in visual or audio formats can be in the students' home language, and the students respond in the target language. The study suggests improved academic performance in such bilingual assessments compared to the monolingual approach. Gorter and Cenoz (2017) also report on better academic performance when students incorporated translanguaging in their responses to bilingual assessments.

Discussion

In most parts of the globe STEM subjects have been taught in a global language, mainly English, rather than using a local language and local curriculum (Babaci-Wilhite 2016). Forty fourth-grade students, 24 girls and 16 boys aged between 10 and 12 took part in this study. All students enrolled in the school in the year 2016 as first-grade students. As stated elsewhere in this article, during their first two years of education, the students used Shona alongside the English language in the classroom. These students and their S &T teacher who took part in this study share a common home language: Shona. This made it possible for the intervention to be effective through dialogue in a language they all understood leading to a deeper comprehension of conceptual knowledge. Through dialogue in a language students clearly understand, teachers shape how students see the world through thematic investigation – the discovery of relevant solutions to societal problems (Freire 1968).

Analysis of the data in the present study suggests that the heteroglossic orientation to pedagogical translanguaging evident in the practice of the experimental group was an important factor in supporting the students' opportunity to learn science (Charamba 2019b). This was necessitated by the fact that translanguaging pedagogy involves building on multilingual students' linguistic practices flexibly and strategically to learn the scientific content as well as new language practices (Ascenzi-Moreno and Espinosa 2018; Charamba & Zano 2019; García and Sánchez 2018; Menken, Pérez Rosario, and Guzmán Valerio 2018). Basing on the difference in the academic performance of the two research groups in the current study, the study suggests teachers in Zimbabwe and the world over need re-think and embrace linguistic practices of multilingual students and move away from monolingual orientations to Science and Technology education (Menken and Sánchez 2019).

The findings of the present study build on and extend the work of other researchers (for example Msimanga, Denley, and Gumede 2017; Probyn 2019; Zhang et al. 2020) as well as that of the author (see for example Charamba 2017, 2019b; Charamba et al. 2019) by offering empirical support for the idea that translanguaging pedagogy empowers multilinguals, enhances their academic performance, and gives them a voice thereby countering the hegemony of English. In the present study, participants in the experimental group showed evidence of changing their linguistic ideologies and science learning as a result of the introduction of translanguaging pedagogy, moving from a monolingual perspective to a multilingual one, and ultimately taking up a translanguaging stance through the use of their linguistic repertoire (Menken and Sánchez 2019).

At the beginning of the study, participants in the experimental group were hesitant to use their language repertoire alongside the English language until Ms. Maidei kept encouraging them by using more than one language in the same lesson. Basing on the findings of the present study, I argue that translanguaging is indeed an effective practical tool for educating multilingual students. Since education in Zimbabwe still follows a monolingual orientation, most students in the country, other than those involved in research, have not been exposed to pedagogy that emphasises the interconnectedness of their language practices and the possibilities inherent in their translanguaging (Charamba 2019b; Gort 2015). The choice and use of language is a humanising act central to a people's definition of themselves with reference to the whole world. The continuous exclusion of students' linguistic repertoire from the education sphere symbolises a continuation of the socially unjust and unconstitutional existence of a multifurcated societal structure (Lamola 2016). To alleviate the prevailing drop out and failure rates, Zimbabwean schools should start viewing students' linguistic repertoire for what it is: an asset.

The present study, therefore, suggests teachers should make multilingual students aware that their ability to translanguage is integral both to their academic success in Science and Technology classrooms (Holdway and Hitchcock 2018). Teachers across the academic sphere should encourage their students to draw from their rich, fluid linguistic repertoire, and move away from the coloniality ways of languaging (Yuvayapan 2019). In Zimbabwe and some countries across the globe, the current status quo is that in any learning area students are required to perform linguistically in the dominant language according to a standardised variety imposed by the majority language community (Charamba 2019a; García and Sánchez 2018).

During the lesson observations, it was interesting to note how the teacher's use of translanguaging pedagogy with the experimental group was pivotal to creating an academic environment where students began to take risks and break out of the monoglossic mold of S & T education (Lin 2019). Due to the prevalent restrictive language policies in Zimbabwe (Charamba 2019a) and some parts of the world, the study suggests it is high time teachers stop working against students' translanguaging as this inhibits their full mastery of academic concepts due to students' low proficiency in the language of instruction (Duarte 2019). Because translanguaging pedagogy establishes relationships between students' linguistic repertoire and the scientific concepts they engage within the classroom resulting in better comprehension (Yuvayapan 2019), the present study advocates for its use across the S & T curriculum.

Conclusion

The teaching and learning of S &T in Zimbabwe suffers from a pedagogy grounded in its colonial history, the stripping of Zimbabwean cultural and natural contexts heightened by the exclusion of her languages from the classrooms (Babaci-Wilhite 2016). Translanguaging in the science classroom makes use of a student's linguistic repertoire facilitating the meaning-making process that can result in increased epistemic access (Lin 2019; Menken, Pérez Rosario, and Guzmán Valerio 2018). This is evidenced in the difference in academic performance between the control and experimental groups in the present study. Basing on the results of the present study, language does play a pivotal role in students' comprehension of scientific concepts. The present study joins the body of research that suggests there is a need to come up with effective pedagogical approaches for multilingual science classes (see for example Ascenzi-Moreno and Espinosa 2018; Jonsson 2019; Meyerhöffer and Dreesmann 2019).

The present study suggests these pedagogical approaches should go beyond using named languages in the same lesson (Charamba 2019b). Stakeholders in education should encourage multilingual students to draw from their rich, fluid linguistic repertoire, thereby moving away from the coloniality ways of monolingual bias in education. In this way, students will make use of their full linguistic repertoire including all the linguistic varieties such as registers, dialects, styles, and accents. Their languaging will become a multilingual, multimodal, and multisensory sense- and meaning-making resource (García and Sánchez 2018; Li and Lin 2019). It is also a way to contribute sustainably to the sustenance of marginalised languages (Shepard-Carey 2020), societal decolonisation, and economic progress by fully exploiting the cognitive and creative potential of multilingual students that comes through the use of their full linguistic repertoire. True decolonisation of education lies not in mere random transferrals of international theories and information but in the acts of cognition brought about through linguistic decolonisation and using students' languages for instructional activities (Freire 1968).

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