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Is Terminology the real Problem in Failure to Implement STEM Education in African Languages? Translanguaging as an Intervention Strategy

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Abstract

English has remained as the sole language of instruction for science, technology, engineering and mathematics (STEM) subjects in Anglophone African countries. The use of English as the only medium in the teaching and learning of STEM subjects has been based on the fact that African languages lack requisite terminology. The paper seeks to answer the questions:

•To what extent are the inadequacies in African languages terminology hindering the teaching of STEM subjects in these languages?

•Is lack or inadequacy in terminology, the real reason for excluding African languages in the teaching and learning of STEM subjects?

•What options can be adopted to achieve the inclusion of African languages in the teaching of STEM subjects?

To answer these questions, the study took a phenomenological qualitative research design which was complemented by textual analysis to interrogate the exclusion of African languages in the teaching of STEM subjects. Semi-structured interviews with 20 teachers of STEM subjects were conducted in Bulawayo, Zimbabwe. The results of the study revealed that while teachers and linguists are aware that the inclusion of the learners' first languages in the teaching of STEM subjects have cognitive benefits, perceived inadequacy in African languages terminologies and fear of isolation remain as hindrances.The study reflected that if African languages in STEM education are included through translanguaging the fears of isolationand misconceptions of inadequacies in terminologies would be conquered.The paper concludes that lack or inadequacy in terminologies in African languages is not a problem but what is the problem is that the inclusion of African languages in the teaching of STEM subjects has been interpreted as a move to totally dislodge English language. African languages and English can be used together in the teaching of STEM subjects through translanguaging.

1. Introduction

To date, many debates have been centred on the use of African languages in the teaching of science and mathematics in schools. These debates have been characterised by varying opinions with some supporting the inclusion of these African languages while other are against their use. Those that have advocated for their use have been trying to fight the marginalisation of African languages and for their recognition since they are the first languages of the majority of learners in Africa. Those that have opposed their use in the teaching of science and mathematics have been basing their arguments on the underdevelopment of terminologies of these African languages and their multiplicity. The paper argues for the inclusion of African languages in teaching and learning of science, technology, engineering and mathematics (STEM) subjects. The arguments advanced in this paper are unique in that we argue for the inclusion of African languages and not for their exclusive. The ideas are premised on the notion of using all available languages in a multilingual classroom in the teaching of STEM subjects and not relegating or excluding any that is available within a multilingual classroom.The paper argues for a harmonious linguistic functionality in multilingual STEM classrooms. On the question of the unavailability of adequate terminology in African languages, we demonstrate that wherever communication is required terms that allow functionality can always be created when strict avoidance of prescriptivism and purism is thoroughly emphasised. Terminology has been identified as a hindrance to the inclusion of African languages in the teaching and learning of STEM subjects yet the approaches where lots of efforts have been invested are the ones that are unrealistic.The paper will also make a critical appraisal of terms for STEM subjects that have so far been suggested by other researchers such as Dlodlo (1999).The idea will be to check on the flaws and strengths of such terms through focusing on cases of purism and prescriptivism that results in awkwardness in such terms.

The paper uses data from semi-structured interviews which were conducted with teachers of STEM subjects. The teachers were interviewed to investigate on the hindrances of including African languages in STEM education. The interview data is complemented by an analysis of terms that have so far been proposed by researchers. Since the study is concerned about the inclusion of African languages in the teaching of STEM subjects in an environment where English is already dominating as a language of instruction, it will be important to use translanguaging as a theoretical framework.

Issues of Language(s) of Instruction in STEM Education

In this section we review literature with the aim of contextualising key issues relating to the place of language in STEM education. STEM subjects that are generally offered at school are usually science and mathematics. We therefore use the term, „science and mathematics" as a substitute of STEM in some instances in this paper. Although STEM, as a discourse and as a practice started as early as in the 1990s in the United States of America (USA) (Berube 2014; Bybee 2013; Mohr-Schroeder,Cavalcanti and Blyman 2015), in Zimbabwe, it was initiated in 2016 as a concept that was adopted from Asian countries. Lee and Tan (2018, p. 2) note that most African countries are enthusiastic consumers on science and mathematics that is taught in Asian countries, while Kim, Chu and Lim (2015, p. 209) note that STEM education has become popular in Asian countries in the past few decades. The teaching of STEM subjects in Asian countries has yielded positive results because of the use of their indigenous languages as media of instruction. (Babaci-Wilhite 2016; Brock-Utne 2012).

There have been mixed reactions from researchers regarding the use of African languages in the teaching of STEM subjects. There are some researchers who are against the use of African languages in STEM education while others are positive about the idea.Bamgbose (2015, p. 22) pauses some questions regarding the possibility of teaching science in African languages. He asks these questions:

> Why not simply go for an imported language such as English?How can a language be used for literacy and as medium of instruction if it is yet to be reduced to writing?How can a language be used for teaching science if there is no terminology already worked out in such languages for the scientific concepts to be encountered?

Bamgbose sums up by saying that, „These are genuine concerns and there is no point in pretending that they are frivolous excuses for the neglect of African languages"(Bamgbose, 2015, p. 22). Rugemalira, Rubagumya, Kapinga, Lwatima andTetlow (1990, p. 31) argue that "It should be demonstrated that countries such as Finland, Norway, China or Japan, which do not teach their children through the medium of an „International" language, are isolated and have lost track of technological developments beyond their borders".Osborn (2010) raises scepticism in view of the multiplicity of these languages which he says according to *Ethnologue* are over 2000 and constituting a third of the total number of languages in the world.This shows that there is a tendency to view African languages in a negative way because of their multiplicity in the contexts of education in Africa.

Weddirage (2009) says that there in not justification to prove that STEM is better learnt in English than in other languages, and that English is the language of science and technology.Babaci-Wilhite (2016, p. 6) is of the idea that "engagement with local language and local knowledge is necessary to facilitate the teaching and learning process". Language barriers related to differences in native language, as well as limited vocabulary, can cause many students to perform poorly on standardised examinations and classroom measures. Research suggests that science learning and student performance can be improved through the increased use of native languages (Banks 2012). Dlodlo(1999) argues that the fact that science and technology in Sub-Saharan Africa is not taught in an African language implies that no scientific ideas could be formulated in an African language or from an African perspective in the present education system. Dlodlo, however, went on to suggest some of the Nguni scientific terms that could be used in the teaching of science.Brock-Utne (2012) argues that most children in Africa are taught in a language that neither themselves nor their teachers master resulting in poor outcomes in science. Nomlomo and Mbekwa (2013) observe that while it is important to use the learners" first language(L1) in the teaching of STEM subjects, these languages are rarely used although South Africa"s language-in-education policy recognises eleven official languages. Parents" negative attitudes towards African languages also contribute to non-use of these languages which are the L1 for the majority of the learners in South Africa (Nomlomo andMbekwa 2013).

It is a widely held view that learners understand better when they are taught in their L1. Babaci-Wilhite (2016) argues that students face challenges in comprehension when they are taught science and mathematics in English at the expense of their local languages. Ranaweera (1976, p. 423) commenting on the shift from English to Sinhala and Tamil in the teaching and learning of science in Sri Lanka said "…it helped to destroy the great barrier that existed between the privileged English educated classes; between the science educated elite and non-science educated masses; between science itself and the people". It gave confidence to the common man that science is within his reach and to the teachers and pupils that a knowledge of English need not necessarily be a pre-requisite for learning science (Ranaweera, 1976).Bangura (2014) calls for the domesticating of STEM subjects through the African mother-tongue. Any subject, even mathematics that has become abstract, can be taught effectively in any language once the appropriate tools are made available (Bangura 2014, p. 14). Although it has been argued for decades that teaching STEM in African languages would be beneficial, there is

nowhere where it is reported that such has been implemented successfully. This is because the approaches that have been proposed and tried are not realistic, and that is the reason why this paper views translanguaging as the ideal tool for teaching STEM subjects in African languages.

Banks (2012, p. 1908) observes that students who are not proficient in English are often restricted in their science learning and performance when instruction, assessment, and evaluation are carried out exclusively or predominantly in English. Brock-Utne (2012) is among those researchers who advocate for the replacement of English with African languages in the teaching of STEM subjects. The argument by Brock-Utne stems from the observation that in Asian countries such as Malaysia and Sri Lanka, children learn STEM subjects effectively in local and familiar languages. Brock-Utne (2012) says that countries in Anglophone need to learn from Asia in order for them to understand that English is not a natural language for STEM subjects. In this paper we are against the idea of replacing English with African languages or the exclusion of any of the learners‟ L1. Instead we are advocating for the use of all available languages through translanguaging as a language practice with the main objective being that of facilitating effecting communication.

Howie (2003) conducted a study to ascertain the background factors that influence secondary school learners‟ performance in mathematics in South Africa.The study revealed that proficiency in English was a stronger determiner of their success in mathematics (Howie 2003). The results of the study by Howie (2003), justify why it is important to consider the inclusion ofAfrican languages as the learners‟ L1 in teaching and learning of STEM subjects.A study by Probyn (2001), on the use of English as an instructional language by learners whom English was their L2 reflected that both teachers and learners get exposed to stress because of inability to communicate freely in English as L2. The teachers had to employ code-switching as a cognitive strategy to enable learners to engage freely (Probyn 2001). Setati, Molefi and Langa (2008) advocate for the deliberate, proactive and strategic use of the learners‟ home languages for instruction in mathematics in multilingual classrooms. Their idea is that such use of languages would ensure that while learners use their languages they also do not lose English which is mostly preferred by teachers, learners and parents because it is perceived as a gateway to success (Setati et al. 2008). Dalvit, Murray and Terzoli (2009) also advocated for the inclusion of learners‟ home languages in the teaching of STEM subjects in South African schools. However, Dalvit et al. (2009) did not suggest the strategies that should be adopted in using English and the learners‟ L1 together. The current study suggests that such an approach can be achieved through the use of translanguaging as a language practice in multilingual classrooms.

Wildsmith-Cromarty and Gordon (2009) studied the use of isiZulu as a home-language in the learning of science and mathematics in English-medium classrooms. The study revealed that in communicating science and mathematics knowledge, complexities such as the involvement of unfamiliar terms that also lacked standardisation led to preference in the use of terminology in English and explanations in isiZulu (Wildsmith-Cromarty 2009). From these findings, it is clear that negative attitudes towards the inclusion of African languages in STEM education are as a result of the lack of specialised terminologies in African languages. Setati (2005) explored the complex relationship between language and the teaching of mathematics in multilingual settings where the teacher shared the same L1 with the learners but the L1 is not the language of instruction in the classroom. Setati (2005) argued that the relationship between the learners‟ L1 and the learning of mathematics should not be downplayed.

Wildsmith-Cromarty (2008) reported on a study that explored the translatability of scientific discourse from English to isiZulu, an African language. The study concluded that the translation of scientific academic material needs to be a consultative and participatory process with closer collaboration among curriculum specialists, translators and teachers (Wildsmith-Cromarty 2008). The ideas advanced in this study differ from those by Wildsmith-Cromarty (2008), in that we are not advocating for documentation of STEM educational material in African languages, but for the inclusion of these languages in communicating content. What is important is not to teach STEM exclusively in African languages but to include these learners‟ first language in academic discourses so as to enhance their cognition. The terms for STEM subjects should therefore be created through transliteration or rephonologisation.

Setati and Adler (2000) commend that South African post-apartheid education policy encourages code-switching as the best instructional strategy for mathematics in multilingual classrooms. Setati and Adler (2000) argue that English language present a lot of challenges for teachers in delivering mathematics lessons in multilingual classes in primary schools. Setati, Adler, Reed and Bapoo (2010) investigated on the use of language practices that include code-switching, exploratory talk, and discourse-specific talk in mathematics, science and English language classrooms in South Africa. Cenoz and Gorter (2020) argued that separating languages when teaching academic content can be problematic because it prevents students from using resources they have previously acquired in other languages. Adler (1998) says that in a mathematics classroom in multilingual settings, all the available languages should be given recognition. Although, Adler (1998) advanced these ideas at a time when the translanguaging discourse was not yet topical, he however was one of the first researchers to talk about the inclusion of available languages in teaching and learning in multilingual classroom contexts.

Other researchers have already indicated that African languages can be included in the teaching and learning of STEM subjects through translanguaging. Lewis, Jones and Baker (2012) argue that translanguaging is an important language practice that enhances cognition amongst learners in a bilingual classroom.Poza (2016) argues for a translanguaging perspective in the teaching of science, whereby language and language acquisition are framed as social meaning-making processes and standardised forms are not maintained. Mazak and Herbas-Donoso (2014) observed that lecturers at a university in Puerto Rico in a Spanish-English bilingual science class, used translanguaging in teaching the students. Probyn (2015) reported on translanguaging by a group of science teachers in rural and township schools in South Africa. A study by Karlsson, Larsson and Jakobsson (2018) describe multilingual students‟ translanguaging practices in a multilingual science classroom.Mbiriri-Hungwe and Hungwe (2018) carried out a research on the use of translanguaging in a multilingual second-year computer science class at a university in South Africa. The results of the study revealed that students perceive translanguaging to be a helpful learning strategy which should be adopted by the whole faculty (Mbiriri-Hungwe and Hungwe 2018).Nhongo and Tshotsho (2019) argued that the use of translanguaging as an instructional method in teaching science and mathematics should be viewed as an important strategy but not as a move towards replacing English with African languages.

While predecessor studies have emphasised on the exclusive use of African languages in the teaching of STEM subjects, this paper takes another dimension in that we are arguing for the inclusion of African languages. By inclusion of African languages, we are saying that English should neither be relegated nor enjoy autonomy in STEM education, but should be used together with African languages. Such a process will be achieved through the adoption of translanguaging as an instructional method.

Conceptualising translanguaging as an instructional method in STEM education

According to Lopez, Turkan and Guzman-Orth (2017), translanguaging refers to the flexible use of the bilingual repertoire. Translanguaging refers to how bilinguals flexibly use their entire linguistic repertoires (Canagarajah 2011; Garcia 2011; Wei 2011).Translanguaging entails transcending or going beyond the two named languages of bilinguals or the three named languages of trilinguals, or the many of multilinguals (Garcia and Kleyn 2016). Translanguaging goes beyond the traditional notions of bilingualism (Lopez et al. 2017) which are code-mixing, code-switching, transference, overgeneralisation of L2 rules and literal translation among others.These language practices are not translanguaging in their own right because they clearly mark the distinction between named languages. Existing terms such as code-mixing and code-switching that assume the existence of named languages as structural and cognitive entities are unable to capture the precise definition of translanguaging (Wei 2018). Its driving force is built on a heteroglossic conception of bilingualism (Lopez et al. 2017). Heteroglossia refers to being and operating in a variety of social discourses situated in a diversity of social languages in a community (Lemke 1998). Translanguaging is contextualised within the linguistic realities of the twenty-first century, especially the fluid and dynamic practices that transcend the boundaries between named languages, language varieties, and language and other semiotic systems (Wei, 2018). Translanguaging allows for the flexible use of named languages by dynamic bilinguals.

Translanguaging as a theory that offers a different view of bilingualism and multilingualism posits that rather than possessing two or more autonomous named languages, bilinguals, multilinguals, and other users of language select and deploy particular features from a unitary linguistic repertoire to make meaning (Vogel and Garcia 2017). This idea is used in this paper to show that the learners‟ L1 can be used together with English as L2 without paying particular attention to the boundaries of the languages that are involved, with the idea of enhancing cognition. Translanguaging pedagogy develops both of the named languages that are the object of bilingual instruction precisely because it considers them in horizontal continua as part of the learners‟ linguistic repertoire, rather than as separate compartments in a hierarchical relationship (Vogel and Garcia 2017).This entails that the use of translanguaging as an instructional method would not lead to incompetence in the learners‟ L1 and L2 but to improvement in the knowledge of the named languages and even to better understanding of the content that is learnt through this language practice.

The study advocates for the flexible use of language in STEM education in multilingual contexts of Africa where English is used as an L2 but is regarded as a language of instruction. One way of countering the hindrances that characterise the exclusion of African languages STEM terminologies in instruction is through transliteration. Transliteration is one way which would allow African languages to be used together with English language with the goal of bringing together all the available languages in the classroom so that cognition is enhanced through effective communication. Transliteration is part of translanguaging and can be understood at the lexical level of language. Transliteration, according to Yuming (2015, p. 231), “maps the letters of the source script to letters pronounced in the target script”. Transliteration requires that the grammatical structures, particularly phonemes and morphemes, of the two languages that are involved become interwoven.

Methods

As way of understanding and exploring the problems that are associated with failure to include African languages in the teaching of STEM subjects, the study uses a qualitative phenomenological research design. Phenomenological research studies emotional, affective, and human experiences (Merriam 2009). This study adopts a qualitative phenomenological research design because it also looks at the teachers‟ experiences in the inclusion of African languages in STEM education. The phenomenology design requires that in order to understand human experiences, there is need for immersive penetration of individual‟s thoughts and insights through employing interviews or extensive discussions (Creswell 2017). In this study, immersive penetration was done by conducting semi-structured interviews with 20 teachers on the inclusion of African languages in the teaching and learning of STEM subjects. The 20 teachers were equitably drawn from 10 secondary schools in Bulawayo, Zimbabwe. The teachers were purposively selected because they taught STEM subjects which included mathematics, general science, biology, chemistry, physics and computer science.

Characteristics of participants and description of materials

Data collection was done through semi-structured interviews which were conducted through face-to-face, phone calls, WhatsApp and email depending on the method that was more conducive for each of the 20 research participants. Sampling was purposeful because the researchers wanted first-hand information from the teachers of STEM subjects on how they included African languages in their teaching, and their experiences concerning language use in their teaching. The teachers were interviewed about their experiences, feelings and about how African languages as the learners‟ L1 should be included in STEM education.

Textual analysis

Interview data with teachers was complemented by the analysis of STEM terms that were proposed by Dlodlo (1999) andthe Department of Arts and Culture of the Republic of South Africa (DACRSA) (2005). A textual analysis of these terms was done in view of the functionality and the cognitive aspect of language.

Ethical considerations

The researchers explained to the research participants that the study was about the inclusion of African languages in STEM education. The ethical consideration, such as ensuring the anonymity of the participants throughout the course of the study was explained to them. The actual names of the participants were anonymised through the use of pseudonyms to secure their personal identity and confidentiality. After this paper was completed, all raw information from research participants was deleted. The following table is a list of pseudonyms that were used in concealing the identity of research participants.

CODE	PSEUDONMY	CODE	PSEUDONYM
1	Bob	11	Tee
2	Alan	12	Jack
3	Stuart	13	Juk
4	Ben	14	Don
5	Sam	15	Dave
6	Jan	16	Netty
7	Lenny	17	Nick
8	Mark	18	Col
9	Matt	19	Garry
10	Tom	20	Kim

Table 1 showing pseudonyms of research participants

Results and discussion

We begin by making a critical analysis of the African languages STEM terms that have so far been put in place.We then evaluate policy regarding the use of languages in teaching of STEM subjects before analysing the teachers‟ views about the inclusion of African languages.

Critiquing the proposed terms for STEM subjects

Dlodlo (1999) and the DACRSA (2005) are among those who have made efforts to come up with terms for STEM education. Dlodlo (1999) proposed terms that can be used in the teaching of physics in Nguni. Nguni languages are spoken in Southern Africa with the bulk of them found in South Africa and these include, isiZulu, isiXhosa, siSwati, isiNdebele of South Africa, isiNdebele of Zimbabwe and isiNgoni of Tanzania and Malawi. Dlodlo (1999, p. 321) says:

> In this article I will propose and show that the best way of creating such vocabulary is to give scientific meaning to generally accessible words that are explanatory of the concepts, rather than borrowing from European languages by phonetic transcription. I will suggest ways of constructing a Nguni nomenclature for physics. It is hoped that the same approach will be adopted for the other African languages.

Whilst Dlodlo‟s efforts of taking the initiative are appreciated, there are however, a lot of shortcomings in his proposal. The first shortcoming in Dlodlo‟s proposal is that he wants to create scientific terms that are purely African where he says he will neither borrow from European languages nor make phonetic transcriptions. What

Dlodlo wants to avoid in his proposed term creation strategies is the exact opposite of transliteration as a form of translanguaging in term creation.While translanguaging is trying to run away from the autonomy of English, Dlodlo is at the same time creating the autonomy of Nguni languages. Translanguaging is against treating each language that is present in a multilingual or bilingual classroom as separate and independent from other languages.

Dlodlo‟s (1999) proposal of coming up with completely new terms that are free from any traces of English would result in further complication of the already existing English STEM terms. Transliteration or rephonologisation of STEM terms that are adopted from English is the best approach that would ensure ease in functionality and cognition, and harmony between the learners‟ L1 and L2. Communicating the contents of the bible in African languages is one of the successes that have so far been achieved since the African languages came into contact with English language. Writing of the bible in African languages was achieved through the use of adoption and transliteration as a term creation strategy. Transliteration conforms perfectly to translanguaging in term creation and such terms that are created through this method have been proven to exert less cognitive burden on language users who are coming from diverse linguistic backgrounds.The avoidance of transliteration is a purist stance that creates a language that does not resonate with twenty-first century linguistic realities of functionality. The following table reflects on some of the Nguni terms that were proposed by Dlodlo (1999). In the table we also put our own proposal of the terms that we presume would be user friendly, not hinder cognition, create harmony between languages and facilitate easy functionality.

SCIENTIFIC TERM (English)	**NGUNI TERM** (Meaning)	**TRANSLITERATED TERM** (Our proposal)
Force	*udli* (use power)	*ifosi*
Particle	*uhlanjana* (very small grain)	*iphathekli*
System	*uhlelo* (a program, an arrangement, a set)	*isistimu*
Energy	*isidlakela* (ability to use force)	*ieneji*
State	*isimo* (the way things are or look)	*isimo*
Process	*isenzeko* (that which happens)	*isenzeko/iphrosesi*
Oxygen	*impiliso* (that which gives life)	*iokisijini*
Hydrogen	*isomanzi* (that with water)	*ihayidirojeni*
Carbon dioxide	*isontuthwini* (that which has smoke)	*ikhabhonidayoksayidi*
Positive (work)	*eyaphambili* (going forward)	*phozithivu*
Negative (work)	*eyaemuva* (going backward	*negethivu*
Opposite	*phambana* (pass the same point in opposite directions)	*ophozithi*
Thermodynamics	*isiDlakhoza/uNyakazokhoza* (heat energy/heat motion	*ithemodaynamiksi*
Equation	*isilinganisa* (that which equates)	*iikhwezhini*
Motion	*unyakazo*(small movements)	*imoshini*
Numbers	*iminwe* (fingers	*inombolo*
Piston	*isivimbonduku* (a stick with a stopper head)	*iphistoni*

Table 2 showing STEM terms proposed by Dlodlo. Adapted from Dlodlo (1999:327)

Our proposal, as indicated in the table is not prescriptive, but we are taking an approach that would facilitate functionality. We haveobserved that the terms that we proposed are being used in Nguni languages in exactly this manner, particularly in isiNdebele, isiXhosa and in isiZulu. Dlodlo is moving away from reality by taking a purist approach and also prescribing terms that are likely to confuse the language users. Being a purist renders Dlodlo‟s proposal flawed because he is trying to simplify the terms and remain pure in Nguni. However, his endeavour in oversimplifying has given result to awkward terms which have the potential to confuse the learner. An analysis of these terms show that the „terminologist‟ is trying to come up with terms that are self-explanatory. Producing self-explanatory terms results in ambiguity and awkwardness. Dlodlo (1999) seems to be ignoring the fact that the L1 speakers of English do not use these STEM terms in their everyday general speech as these words belong to specialised subject fields. Another fact is that some of these STEM terms have come into English through adoption from other languages and then having them go through the process of transliteration so that they conform to the phonological and morphological habits of English language. This is the reason why it is common that when a term from a specialised subject field is being defined, it would be like, „this is a Greek word, a Latin word, a French word and so on‟.

The DACRSA, in 2005, came up with grades 4 to 6 sciences and technology terms for Nguni languages which include isiZulu, isiXhosa, siSwati and isiNdebele. A number of strengths can be identified in the terms that they created. First, unlike Dlodlo (1999), they adopted transliteration as a strategy especially where the term has not previously existed in the language. For the word „hydrogen‟, they used „*ihayidrojini*‟; for oxygen, they used „*i-oksijini*‟ for isiZulu, siSwati, and isiNdebele; and for „carbon dioxide‟, isiNdebele uses „*ikhabhoni-dayoksayidi'*. Another strength demonstrated here, especially for Xhosa is that they also incorporated some of the terms that

they were already using in the language unlike Dlodlo who tried to replace already existing terms with new ones. For Xhosa, for instance, hydrogen, has before been referred to as „*umngxengamoya*", and „oxygen" as „*umongomoya*". The two terms have been maintained although „*ihayidrojini*" has been added as a synonym for „hydrogen". Another strength in these terms is seen in the provision of variations as referents for a single concept. For „oxygen", isiZulu uses „*umoyampilo*", „*umoyaohlanzekile*" and „*i-oksjini*". Although using a single term for a particular concept may be viewed as a strength, it should however, be noted that these African languages have dialects and that the moment there is too much strictness on standardising terms, such may be viewed as prescriptivism and is dangerous to language development. Kageura (2002, p. 19) argues that "the standardisation of terms is by its very nature prescriptive and cannot be part of what we currently understand by *theory*". Kageura further argues that combining the claim of systematicity in term creation with standardisation is however, not only irrelevant to the scientific study of terms but also harmful to the practical aim of standardisation.

Oversimplification and trying to make STEM terms self-explanatory in Nguni languages was identified as the major weaknesses in Dlodlo (1999) and DACRSA (2005) as such terms become awkward. Translanguaging in Africa is not as new as it is defined, but it is as old as the first encounter of African languages with European languages. Translanguaging is noticeable in language practices that were as a result preaching the Christian gospel in African languages. Efforts to translate the bible into African languages were fruitful because transliteration as part of translanguaging dominated the process. Today there are many terms that we find in Nguni languages which came as a result of transliteration and some of such terms have even become accepted as purely African and some have replaced some Nguni terms that were in existence.

The current linguistic situation in teaching STEM subjects

Since the study was conducted in Zimbabwe, particularly in schools in Bulawayo, it is prudent to briefly outline the contents of the language-in-education policy of Zimbabwe. We also make reference to Nguni languages in South Africa because isiNdebele, which is the predominant language in Bulawayo is also a Nguni language. Ndebele shares the bulk of its lexicon with the Nguni languages of South Africa, particularly isiZulu. IsiZulu texts re used to compliment those of isiNdebele in the teaching of isiNdebele as a subject in Zimbabwe.

The curriculum states that English shall be the main medium of instruction although the learners" L1 can also be used as resources (Ministry of Primary and Secondary Education, 2014, p. 34). The Education Amendment Bill (2019) of Zimbabwe, section 4.10 states that:

> The Bill provides that every school shall endeavour to teach every officially recognised language while making sure that the language of instruction shall be the language of examination. The Bill also ensures that the mother tongue is to be used as a medium of instruction at early childhood education.

While the curriculum acknowledges that the African languages should be included in education the challenge is that emphasis is put on teaching these languages as subjects. Their use as media of instruction in other subjects is unclear although it is highlighted that they can be used as resources. There seems to be emphasis on monolingualism where it is said that the language of instruction is the language that shall be used for examination. The Ministry of Primary and Secondary Education(MPSE) is not clear on the role of African languages in education as to whether they should remain being taught as subjects or they should also be used as media of instruction in the teaching of other subjects. During the interviews, teachers demonstrated that they were not sure as to how exactly they were supposed to treat the issue of language use in teaching because the government is not clear on that matter.

How African languages are included in the teaching of STEM subjects

The general observation that came out from the interviews with teachers was that African languages should be included in the teaching of STEM subjects although the MPSE has no clear position on the extent to which the languages should be used. The teachers indicated that the teaching of STEM subjects to learners who are L1 speakers of African languages cannot be successful if instruction is restricted to English language only. The teachers also indicated that when they are teaching they make emphasis through giving further explanations in African languages, particularly isiNdebele and sometimes Shona in Bulawayo. The teachers highlighted that it was going to be easier to teach STEM if African languages terminologies were available.

The major drawback over the inclusion of African languages in the teaching of STEM subjects was the unavailability of terminology in these languages. The teachers were concerned about the terms that would be used to refer to some of the STEM concepts. Kim said:

> *It is a good idea to use vernacular in teaching science and mathematics. But my worry is on the words that are going to be used to call some of the things that the children learn aboutin the science subjects. What words are we going to use to call 'potassium', 'osmosis', 'diffusion', 'photosynthesis', 'quadratic equation', 'square root', etc. I think it can take hundreds of years trying to come up with words that will represent these things in vernacular.*

Similarly, Sam said:

> *It can be difficult to teach STEM subjects in Ndebele or Shona or any other indigenous language because we do not have the vocabulary in these languages. Just imagine all those scientific and*

> *mathematical words, how do you put all those words in vernacular? Who will be responsible to come up with words that will be used in physics, maths, chemistry, biology and so on?*

Nick was of the view that:

> *If we are to use these African mother-tongue, then learners are likely to be more confused than they do now. The words to be used in science and mathematics that can be put in local languages will confuse the learners. Just imagine all the science and mathematics vocabulary that we use now being put in African local languages. There will be too much confusion*.

The sentiments from the research participants are that whilst it is a good idea to include African languages in the teaching of STEM subject, the unavailability of terms to be used will be the major challenge. The teachers were worried about terminologies because of the treatment of languages as separate entities that should enjoy autonomy. In STEM education, languages should be viewed as tools for functionality that should facilitate communication and the transmission of knowledge rather than regarding the standardised lexicon of a named language as a storehouse of knowledge. Kageura (2002) is against the standardisation of STEM terms in education because that limits the learners‟ creativity and imagination.

There was also a suggestion of some terms that could be used in STEM education. Jack gave the suggestion as follows:

> *Oxygen can be called 'umoyampefumulompilo' (*air/gas we breathe to get life*), carbon dioxide can be 'umoyakulahlwa' (*air/gas emitted*), hydrogen to be 'umoyamanzi' (*watery air/gas*).*

On the other hand, Garry gave the following suggestion:

> *My suggestion is that we can call oxygen 'umoyampiliso' (*air/gas that gives life*), carbon dioxide 'umoyaongelampilo' (*air/gas with no life*), and hydrogen as 'umoyawamanzi' (*air/gas for water*).*

Netty said:

> *There is nothing new in using African languages in communicating STEM concepts. There is no need to talk about translation of texts or coming up with new words because the teaching and learning of these STEM subjects can be done in same manner in which we use language every day when we are talking about concepts such as cell phones, computers, tablets and so on because we communicate these things every day but when it comes to science we want to complicate things.*

What can be observed these suggestions no longer represent terms but they are self-explanatory statements. They are more of definitions than terms and such awkward labels are likely to result in ambiguity and confusion.

There are fears that were raised by the teachers concerning the inclusion of African languages in the teaching of STEM subjects. Ben‟s fear was that:

> *Teaching STEM subjects in vernacular is good but where do we get words to represent those that we find in textbooks that are written in English? Are all the textbooks going to be translated into Ndebele and how long is that going to take? Will the government be willing to undertake such a big job? We have 16 languages according to the constitution, how is that going to be possible to have science and maths taught in all those languages? My mother-tongue is Shona and am teaching here in Bulawayo so Ndebele can be a problem at times so how is all that going to be done throughout the country?*

Mark expressed his fears in the following words:

> *Remember that learners in our classes speak mainly Shona and Ndebele, so are we going to have a teacher who will be able to speak, hear and understand STEM terms from all these languages? I think that English should continue being the language of teaching although at times teachers can make clarification using vernacular.*

Another fear was raised by Tom in the following sentiments:

> *If learners are to be taught in vernacular, then they are going to be limited to Zimbabwe only because they would have limitations in being able to communicate with others outside Zimbabwe. They are not going to be able to operate outside the country, their knowledge will only be used in Zimbabwe. If they are called for interviews they will be outshined by those who were taught in English*.

Similarly, Alan said:

> *The use of mother tongue would limit the learners not only to Zimbabwe but to specific regions within the country because of language differences. The Tonga will be limited to function in Binga, the Sotho in Gwanda, the Venda in Beitbridge and so on. The use of mother-tongue also has the potential to divide people within the country because of the creation of regionalism. It means that each person will be trained to serve the people who speak the same language with him/her*.

Other concerns that teachers raised were on assessment. The general concerns raised by the teachers were about which language was going to be used in assessing the learners. Another concern was that the inclusion of African languages was going to limit the learners‟ proficiency in expressing themselves in English language. Bob‟s concerns were as follows:

> *If the learners are taught in African languages, then are they going to write exercises and examinations in those African languages or English?The use of African languages is bound to create confusion to both teachers and learners when it comes to assessment.*

Tee said:

> *The use of vernacular can result in learners becoming lazy to perform in English as a second language. They may become reluctant in the use of English once African languages are introduced as an option in the writing of examinations.*

Matt was of the idea that:

> *If the learners are allowed to include their mother-tongue in learning, then they should also be allowed to use their languages in writing examinations and exercises. The marking of examinations is likely to be problematic because not all teachers will be well versed with the many languages that are spoken in Zimbabwe.*

The fears that were raised by the teachers are not what translanguaging entails. The idea of the inclusion of African languages which this paper advocates for is not meant to isolate the languages but to use them together through a process of translanguaging, with the objective being that of enhancing cognition amongst the learners. The learners would understand better if their L1 and L2 are included through translanguaging. The inclusion of African languages in teaching and learning of STEM subjects does not entail that assessment should be done in African languages. It has been proven that when bilingual learners are taught through translanguaging, they also develop proficiency in both their L1 and L2 (Childs 2016; Karlsson et al. 2018;Vogel and Garcia 2017). The learners can therefore be assessed in any language that the examining body requires because learning through translanguaging does not retard learners from being proficient in any of the languages that are involved.

It is also important to look at how teachers include African languages in the teaching of STEM subjects. The teachers indicated that in their teaching they either use the English first then make further explanations in an African language, or use an African language first then make explanations in English, or use both languages concurrently throughout the lesson. Dave said:

> *I introduce the lesson in English and then after I have taught in English I then explain in Ndebele after doing that I that I then ask learners to explain in both Ndebele and English, then with time I they will be able to explain the science concepts in English.*

Bob narrated his experience in teaching „ecosystem" to a form 2 class:

> *Where I learnt the usefulness of the use of vernacular which is the mother tongue of the learners is when I taught a topic on ecosystem and I was using English since it was the norm that teaching was supposed to be done in English. There was a senior student in my class when I was teaching that topic whom I had asked to come and perform a small task for me while I was teaching. This senior student was one of the most intelligent students in the school. When the lesson was over the student approached me and told that those junior students that I was teaching did not hear anything because I was using English only. Next day I gave them a test and they all performed badly even the most brilliant ones. On the other day I then taught them the same topic using both English and Ndebele and discovered that the level of participation was high. I gave them the same test that they had failed before and all of them performed very well. From that day I now use both Ndebele and English when I am teaching.*

Lenny said that he discovered that the use of learners" L1 and L2 is a necessity in teaching:

> *I was using Ndebele together with English in my mathematics lessons until the headmaster discouraged me when he came for lesson observations saying that the ministry did not allow the use of vernacular in teaching maths. I then had to stick to English only but at the end of the term the learners performed dismally. I resorted to my previous style of using English and vernacular at the same time and then noticed that the pupils were now performing better. It is better to go against the law and produce good results that to stick to the law that you know that it does not work, it is killing the learners.*

Don said:

> *It is important to begin with Ndebele when teaching so that learners understand fully what you are saying and when you switch over to English they already have a full clue of what you are talking about in a science lesson.*

Other teachers said that it is beneficial to begin by teaching in English and then make explanations in the learners" L1. Col was of the idea that:

> *A STEM lesson has to begin with English before moving on to vernacular. If you begin with vernacular learners are likely to relax when it comes to English and therefore they may not improve in English which is the language that they are expected to be assessed in. It should not always be the case that teachers would always make clarifications in vernacular because the learners would not improve in English and they would tend to relax knowing that there would be spoon-feeding.*

Netty was of the view that:

There is no need to separate the languages when teaching. Both vernacular and English should be used at the same time and each language should come in to serve a purpose where it is necessary to bring it in.

The teachers had different views regarding the approaches that should be adopted in the inclusion of African languages in STEM education because the ministry of education has not been clear as to how these languages should be utilised. Translanguaging is the best approach that should be adopted as way of utilising African languages as valuable resources in STEM education. Over the years, translanguaging has proven to be an effective pedagogical practice in a variety of educational contexts where the school language or the language-of-instruction is different from the languages of the learners (Wei 2018:14). Teachers need to be aware that African languages should not be separated from English for the sake of making it clear that they are included. What is important is to use these languages strategically as way of scaffolding STEM education through a process of translanguaging.

Conclusions

If transliteration, as part of translanguaging is considered in communicating material for STEM subjects, then terminology cannot be regarded as a hindrance in the inclusion of African languages in teaching and learning. The best strategy to be used in the creation of STEM terms in African languages is to use transliteration which in the same strategy that was used in writing the bible in African languages. The route which many linguists and teachers perceive as the best to be taken towards the creation of STEM terms in African languages is not in sync with twenty-first century linguistic realities. In creating the STEM terms functionality should come as the first priority. Purism and prescriptivism will create a situation where the terms that are created will be awkward and will never be accepted by language users on the grounds that they will burden the learners‟ cognitive abilities. Translanguaging would not create confusion as these terms would not become too different from English whose literary tradition in STEM is highly developed not only in Zimbabwe but in Africa and beyond. English has grown to become a global language because it has been adopting terms from other languages through transliteration.The fact that English has become a global language is a reality that no one can easily ignore. African languages should therefore not be made to receive recognition through replacing English language but they should be recognised through being used together with English. The negative attitudes arising from fear of isolation and lack of proficiency in English would be overcome if African languages and English are not viewed as standalone languages in STEM education.

If transliteration is used as a term creation strategy for STEM subjects, then the difference between terms in English and those in African languages would be minimal. As such mutual intelligibility in language in the field of STEM would be created between English and African languages and also between African languages om their own. That mutual intelligibility would suit well the multilingual nature of African classroom contexts and would create cognitive advantages. If these facts are considered carefully, then one can come to the conclusion that the inclusion of African languages in STEM education is failing because of the adoption of approaches that are not addressing linguistic, functionality and cognitive realities. From the time that English first came into contact with African languages people have been accommodating concepts in the African contexts through translanguaging and communication has always been going on smoothly. The same approach that is used in everyday general ordinary speech should be applied in STEM education.

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