Knowledge beyond colour lines

Towards repurposing
knowledge generation in
South African Higher Education

EDITORS

Monwabisi K. Ralarala

Lorraine S. Hassan

Rajani Naidoo

14 INSIGHTS INTO STUDENT TEACHERS' IDENTITIES AND PERSPECTIVES ON THE ROLE OF LANGUAGE IN SCIENCE EDUCATION

Vuyokazi Nomlomo

Introduction

The language of learning and teaching (LoLT) remains a contentious issue in basic and higher education in Africa due to the dominance of colonial languages (for example, English, French, Portuguese, Arabic) and the low status of indigenous African languages in education. The use of colonial languages as the main LoLT remains a key barrier to learners' epistemological access to knowledge, especially among African-language speaking learners on the African continent.¹ The mismatch between the LoLT and learners' mother tongues becomes an additional educational challenge to many learners in disadvantaged communities already confronted with a plethora of socio-economic factors, such as poverty, lack of resources, conflict, and inadequate teacher training (Campbell, Marx, Wilson, Perold & Jooste, 2007). These factors impede learners' language development, cognitive growth and perpetuate linguistic and social inequalities (Brock-Utne, 2005; Hewitt-Bradshaw, 2012; Prah, 2007).

In knowledge construction in science teaching and learning, language plays an important role.² Many research studies show a significant relationship between learners' home language and meaningful learning in science, technology, engineering and mathematics (STEM) subjects.³ The negative effects of using an additional or foreign language as the main LoLT in science have been widely documented.⁴

¹ Alexander, 2005; Alidou, 2003; Chetty, 2012; Makoe & McKinney, 2014; Mazrui, 2002; Mkhize & Balfour, 2017; Nomlomo & Khuzwayo, 2019; Ogunniyi, 2019a; Prah, 2007; Webb, 2004.

² Essien, 2018; Msimanga, Denley & Gumedé, 2017; Nomlomo & Khuzwayo, 2019; Ogunniyi, 2019a, 2019b

³ Campbell et al., 2007; Essien, 2018; Hewitt-Bradshaw, 2012; Msimanga, Denley & Gumedé, 2017; Nomlomo, 2007; Ogunniyi, 2019a.

⁴ Campbell et al., 2007; Hewitt-Bradshaw, 2012; Jarrett, 1999; Ogunniyi 2019a, 2019b; Rohandi, 2017.

'Language' 'is an important tool for communication in STEM subjects; many learners struggle to grasp scientific language different from everyday language (Lemke, 1990). Science has a specialised language regarding its syntax, grammar, discourse features and vocabulary (Helmenstine, 2019; Hewitt-Bradshaw, 2012; Jarrett, 1999). Science concepts are often communicated in graphs, charts, mathematical symbols and equations (Helmenstine, 2019; Jones, 2000), which learners do not easily understand because of their unique features (Jarrett, 1999). Strong language skills in the LoLT are required to express these concepts in different forms, such as discussions, arguments, narrations and descriptions. As most learners are taught through the medium of English in South Africa, limited English proficiency and the complex language of science become epistemological obstacles.⁵

In addition, many science teachers have a limited understanding of the impact of English as LoLT on STEM subjects, which have specialised language.⁶ In situations where teachers and learners have limited proficiency in English as LoLT, and the teachers had insufficient teacher education, teachers struggle to manage the cognitively demanding science subject content and language, and English as LoLT (Campbell et al., 2007; Essien, 2018; Hewitt-Bradshaw, 2012; Ogunniyi, 2019b). This limitation often affects learners' academic achievements in science, as is evident in many South African learners' poor achievement in high-stake examinations, such as the Trends in International Mathematics and Science Study (TIMSS). Few students, especially black students, pursue further education opportunities in STEM subjects; and this remains a concern (Campbell et al., 2007; Ogunniyi, 2019a), especially as STEM subjects are considered essential for every country's future prosperity and economic growth (Campbell et al., 2007).

Science teaching entails immersing learners in science's appropriate academic language through thinking, speaking, reading and writing (Mensah, 2007). The teacher's language identity, the choice and use of the language of instruction, and classroom practices all become crucial in this regard (Mahboob, 2016). Teaching science in a second language involves teaching in the classroom interaction language (LoLT). The subject content and scientific language have a unique vocabulary often challenging to the teacher and learners (Essien, 2018; Mensah, 2007).

While there has been increased research on the role of language in science teaching and learning in basic and higher education over the past two to three decades globally,⁷ there is still a gap in the literature regarding student teachers' views on the interplay between

⁵ Essien, 2018; Mensah, 2007; Nomlomo & Katiya, 2018; Nomlomo & Khuzwayo, 2019; Nomlomo & Mbekwa, 2013; Ogunniyi, 2019b; Prah, 2007; Probyn, 2006.

⁶ Campbell et al., 2007; Essien, 2018; Jarrett, 1999; Ogunniyi, 2019a.

⁷ Campbell et al., 2007; Chung-Parsons & Bailey, 2019; Essien, 2018; Helmenstine, 2019; Hewitt-Bradshaw, 2012; Jarrett, 1999; Lemke, 1990; Nomlomo & Khuzwayo, 2019; Nomlomo, 2007; Ogunniyi, 2019b.

language, teacher identity and science education. I argue that if language and science are key factors in the educational and socio-economic development agenda of South Africa, it is imperative to uncover student teachers' identities and the impact of these identities on science teaching and learning, particularly in culturally and linguistically diverse classrooms.

In light of the above, this chapter reports on the findings of a qualitative case study conducted with a group of fourth-year bachelor of education (BEd) student teachers specialising in science education in a South African higher education institution. The study drew on teacher identity (Chung-Parsons & Bailey, 2019) and Gee's (1996) discourse theory to gain insight into student teachers experiences of the role and impact of English as LoLT on their science learning at school and on their training as prospective science teachers for the senior phase (Grade 7-9). In general, teacher training requires integrating different theoretical and practical knowledge (Nomlomo & Sosibo, 2016), and language is crucial in facilitating this type of knowledge. These two questions guided the qualitative study:

- What are the student teachers' experiences of using English as the main LoLT in their learning of science in basic and teacher education?
- How does English as LoLT influence the student teachers' identity construction and pedagogical practices as novice science teachers in the senior phase?

This chapter proceeds from the premise that there is a relationship between language use and student-teacher identities that influence their science education practice. As a point of departure, the chapter conceptualises teacher identity to understand the link between language and science teacher identity.

Language and teacher identity

The concept of identity originated in the twentieth century in the sociology and psychology disciplines and later evolved as part of a dynamic process in the social psychology field (Leserth, 2013; Olsen, 2008). Research on teacher identity gained momentum at the beginning of the twenty-first century. Identity in teacher education and training is defined as personal and professional characteristics of becoming a teacher (Søreide, 2007), integrated into the content and pedagogy within a specific teaching-learning context (Pennington & Richards, 2016). In other words, it sheds light on the qualities of becoming a teacher and the types of knowledge that have to be acquired in teacher education programmes. Hence some identity studies focused on student-teacher development and subject matter (Søreide, 2007), while others applied a sociocultural approach to understanding individual teachers' experiences (Cardelle-Elawar & Sanz de Acedo Lizarraga, 2010; Søreide, 2007). These studies suggested that teacher identity is a multidimensional entity central to understanding how teachers learn and develop (Avraamidou, 2016).

Teacher identity is shaped by teachers' histories, beliefs, values, attitudes and practices that influence learners' identity development with regard to their values, goals and worldviews (Chung-Parsons & Bailey, 2019). Teacher identity formation is a complex and continuous process shaped by personal experiences and contextual factors, such as the language used in teaching and learning (Leibowitz, Adendorff, Daniels, Loots, Nakasa, Ngxabazi, Van der Merwe & De Venter, 2005; Rus, Tomsa, Rebega & Apostol, 2013).

As highlighted above, the key elements of teacher identity include language usage, classroom practices and curriculum delivery (Mahboob, 2016). Teachers use language to negotiate meaning in the classroom; through their language choice, they often convey elements of their identity such as their personal histories, beliefs and values, all of which influence their teaching practices (Avraamidou, 2016; Mahboob, 2016).

Some researchers claim that student teachers begin to acquire the knowledge to teach before entering teacher training programmes (Chung-Parsons & Bailey, 2019). For example, student teachers' science identities are shaped when they are learners (as they are exposed to their own science teachers' histories and beliefs) and their own historical and contextual experiences (Chung-Parson & Bailey, 2019; Hewitt-Bradshaw, 2012). These, in turn, influence how they interact with learners in the classroom. Chung-Parsons and Bailey (2019) refer to teacher identity as comprising both professional and subject matter identities. Teacher 'professional identity' evolves over time and is shaped by how, and to what extent, teachers identify with the teaching profession (Tateo, 2012) while 'subject matter identity' incorporates pedagogical knowledge, signifying how and to what extent teachers identify with the subject(s) they teach (Chung-Parsons & Bailey, 2019). Subject matter identity is perceived as the most important teacher identity element influenced by teacher performance, competence and recognition by learners and other teachers in the discipline (Chung-Parsons & Bailey, 2019).

While all student teachers develop teacher identity in their training, science teacher identity specifically develops when student teachers begin to identify with scientists and the scientific community, including the language of science (Chung-Parsons & Bailey, 2019). They must demonstrate knowledge of the critical modes such as graphs, formulae, and terminology used to enhance learners' understanding of science (Airey & Linder, 2009; Hewitt-Bradshaw, 2012). They should help learners use the specialised language and vocabulary of science instead of the everyday language used in their sociocultural environment. Therefore, it is relevant to explore the relationship between language, identity and how language is used in science teaching and learning (Gee, 1996; Mensah, 2007). For this reason, I draw on Gee's discourse theory to map out the intersection between language, teacher identities and science discourse.

Understanding science discourse

Gee (1996, 1999) distinguishes between 'Discourse' (denoted by upper-case 'D') and 'discourse' (lower case 'd') to illustrate the connection between social relations and contexts and how language is used in specific situations. The capital 'D' describes how social groups use language to perform activities that reflect their social identities, manifested in their culture and vernaculars that are non-specialised languages (Gee, 1996). On the other hand, the small 'd', embedded within the big 'D', refers to how a group of people use written or spoken language to interpret or make sense of a particular phenomenon (for example, jargon, colloquial language).

Gee's (1996) theory entails 'apprenticeship' associated with Vygotsky's (1978) sociocultural theory. Through apprenticeship, students become immersed in the discourse (d/D) by interacting with people who have already acquired it. In other words, apprenticeship to master both kinds of discipline discourse involves scaffolding, active interaction and collaboration between less experienced and more experienced individuals. People who join a particular discourse community have to interact with competent members of that particular discourse community (MacKay, 2007). For example, in science teaching and learning, learners have to engage with their teachers and other knowledgeable people, such as scientists, to learn the scientific discourse and make meaning of scientific content. Wenger-Trayner (2015) refers to this practice as apprenticeship within a community of practice, formed by a group of people who share common identity and interests and interact and learn from each other. The group of people display an identity associated with a Discourse (MacKay, 2007).

Language is a key element in science discourse (Airey & Linder, 2009; Gee, 1996) because "learning science means learning to talk science" (Lemke, 1990:16). Concerning science teaching and learning, the little 'd' and the big 'D' discourses indicate that science has its own culture of power (Mensah, 2007) that determines one's access to, or exclusion from, content knowledge. As science activities, such as observations, descriptions, comparisons, analysis are performed through Discourse, teachers and learners must understand both the LoLT and the language of science as 'd' discourses. In cases where the LoLT is not the teachers' nor learners' primary languages, it may be difficult to make meaning of the science content. Therefore, teachers should know what language modes (for example, formulae, graphs and calculations) learners have to acquire to master the science discourse (Airey & Linder, 2009; Prain, 2004). In this sense, the scientific discourse can be regarded as both a cognitive and social construct, acquired through the teacher's facilitation to enhance meaning-making and learners' access to scientific knowledge or literacy (Agarkar, 2019).

According to Gee's (1996) 'd' and 'D' theory of discourses, the language of science acts as a gatekeeper, admitting some and excluding others, due to its complex discourse (Mensah,

2007), usually very different from the science learners' sociocultural experiences and context. Muralidhar (1991) claims that even students whose mother tongue is English often experience difficulties dealing with the complex and specialist science discourse. The situation would be more challenging for second- or third-language English speakers because many scientific texts (journals, for example) are published in English.

In South Africa, this challenging situation would not be different for student teachers who have gone through the same education system as their learners: the use of English as LoLT is one of the major challenges in basic and higher education (Nomlomo, 2007; Nomlomo & Khuzwayo, 2019; Ogunniyi, 2019a). It is against this backdrop that this chapter focuses on exploring student teachers' experiences of English as LoLT and the impact of these experiences on their identities as prospective science teachers in the senior phase.

Research methodology

The research was based on a qualitative case study conducted in one higher education institution in the Western Cape. A case study provided the opportunity for studying a problem in-depth within a limited time (Bell, 2010). The sample comprised 12 fourth-year BEd student teachers drawn from a class of 19 students who specialised in senior phase science education (Grades 7-9). The purposeful and convenient sample comprised seven female and five male volunteers who participated in the study and were easily reached to fulfil the study's purpose. The students' ages ranged from 22-27 years, and they were in their final year of study and had enjoyed more exposure to the classroom environment through teaching practice than other student teachers. They would have had fairly extensive student teaching experience by the fourth year, so they could be expected to respond better to questions that required them to explain their experiences with English as LoLT during their interaction with Grade 9 learners in the school science classroom.

The sample contained no home language English speakers because most students (11/19) in the fourth year BEd class had Afrikaans as their home language, although they were taught in English as LoLT from primary to higher education. The sample (12) consisted of seven Afrikaans home language speakers (four females and three males), four isiXhosa speaking students (two females and two males) and one isiZulu speaking student (one female).

Data were collected through an open-ended questionnaire; focus group interviews were conducted with the students. Apart from accessing their biographical details, the questionnaire elicited information on the students' opinions on the role of language in science teaching and learning and their experiences of learning science through the English medium when they were school learners themselves and when they interacted with Grade 9 learners during teaching practice. The aim was to explore the students' personal language

identities and how their experiences had influenced their earlier and later learning and their teaching science experience as student teachers in schools.

Two focus group interviews were conducted, each involving six students. The two focus groups were selected based on availability and convenience as two sessions were negotiated with them in advance. These focus group interviews complemented the data gathered previously from the questionnaire as the focus group questions probed students' responses to questionnaire questions about their experiences of learning science through the medium of English. The interviews aimed at understanding how student teachers facilitated science learning in linguistically diverse classrooms and at uncovering how their language identities influenced their learning as novice teachers, especially regarding disciplinary and pedagogical knowledge construction.

Research ethics adhered to in conducting this study were, for example, informed consent, voluntary participation and anonymity (De Vos, Strydom, Fouché & Delport, 2005). The participants were consulted in advance; permission was sought from the institution to conduct the study.

The focus group interview data were audio-recorded and subsequently transcribed. Data from the questionnaire and interviews were analysed according to themes (De Vos et al., 2005) that correspond to the research questions underpinning the study mentioned above.

Research findings

Two main themes emerged from data analysis:

- the impact of English as LOLT on teacher identity and science knowledge construction; and
- the science discourse and student teachers' pedagogical practice.

Impact of English as LoLT on science teacher knowledge and identities

Concerning the role of language in teacher education, the focus group interview data revealed both the positive and the negative impacts of English as the main language of communication and LoLT in the teaching-learning process. The positive responses reflect the role of language as a key tool for communication in society. The following excerpts are drawn from the focus group interview data:

Language plays an important role in having people communicate (Excerpt 1).

Everybody has to communicate through a particular language, and language is used for teaching all subjects in schools and universities (Excerpt 2).

Section IV | Blended pedagogies and knowledge sharing issues

Languages are important in learning, although “others” [other languages] are more important ... English, for example, ... (Excerpt 3).

In the first two excerpts (both from Afrikaans speakers in Focus Group 1), the speakers concur that language is central to communication in society and classroom interaction. While the third view from an isiXhosa home language speaker (Focus Group 2) acknowledges the importance of language in learning, she also alludes to language inequality, given English's hegemonic status. As indicated earlier, none of the learners were home language English speakers. However, they appear to have invested in English as the dominant language in education, a common practice among English second-language learners who tend to invest in the community's most prestigious language for socio-economic benefits (Gee, 1999). This is also a familiar attitude towards English's prestige in South African education (Makoe & McKinney, 2014; Nomlomo, 2007).

All the students (12) concurred that a student's home language influences one's access to knowledge across the curriculum. However, eight student teachers raised concerns that most university students were not mother-tongue English speakers, the main LoLT in higher education. As a result, most students experienced difficulties in accessing science knowledge through the medium of English. This seemed to affect their teacher knowledge in terms of interaction with learners at schools since they lacked the confidence to speak in ‘pure English’. Two Afrikaans and isiZulu-speaking students had this to say:

I feel that English language can be a huge barrier to learning, since a lot of us find it difficult to be taught in a language that is not our home language If students are taught in their home language, it is more likely that they will excel in science (Excerpt 4).

For those students with a home language other than English, it is a big problem. This is a very big learning barrier and might inhibit the true potential of *varsity students*, especially when you have to *stand in front of learners* (Excerpt 5) [Author's emphasis].

The two excerpts (4 and 5) indicate the student teachers' language identities as non-mother-tongue English speakers (Afrikaans and isiZulu, respectively), with limited proficiency in the language. They also acknowledge that English as LoLT is a barrier to learning and assume that learning science through their home language might be easy. This view does not seem to consider the unique and specialised scientific language a challenge to both home language and second-language English speakers (Muralidhar, 1991).

These responses are in line with the view that student teachers develop science identities through performance, recognition, and their experiences, all influenced by their sociocultural environments (Chung-Parsons & Bailey, 2019). The student teachers do not seem to identify with the English language (D), although they have had to acquire the discourse to master science and its specialised language (d). The students' responses

portray the privilege those who speak the dominant language enjoy and imply that English as LoLT and science's academic language impedes students' access to meaningful learning.

Excerpt 5 illustrates the student's identity ('varsity student') and the negative impact of the LoLT on his pedagogical practice ('standing in front of learners'). It highlights the intersection between language and teacher identity that manifests itself in how teachers interact with their learners in practice (Chung-Parson & Bailey, 2019; Lemke, 1990).

Some of the student teachers acknowledged their limited English proficiency and how this affected their confidence and performance with regard to discipline and classroom management. One of the students who was an isiXhosa home language speaker (Excerpt 6, below) expressed how her limited English proficiency impacted her confidence:

You do not have confidence, and children can hear when you are breaking English ... they do not listen to you and make noise. They laugh at you and you feel awkward You become a joke ... (Excerpt 6).

The above excerpt can be explained by Lemke's (1990) observation that science teaching is a social process influenced by the values, interests and attitudes that both teachers and learners bring to the classroom. The data indicates that the student teachers' limited English proficiency as LoLT may negatively influence their ability to communicate the subject matter to learners. In this way, the individual student-teacher positions herself in relation to the learners' attitudes and expectations. In addition, the specialised science terminology (Mensah, 2007) and low proficiency levels in English as LoLT could exacerbate the student teachers' low self-esteem and affect their science teacher identity development (Chung-Parsons & Bailey, 2019). This puts the student teacher and the learners at risk with regard to subject content quality and their meaningful access to science literacy.

While some of the student teachers acknowledged the disadvantages of learning through the medium of English as LoLT, others perceived English as a means of accommodating diversity, especially for foreigners who do not speak any other South African languages, as shown below:

English should be used as the language of instruction nationwide It is OK since it is a *universal language* which means they can use it to bridge their understanding of other *people from a foreign place*, but it is also hard for *people in South Africa* since the majority of them *do not use English* as their home language and only get exposed to it at a later stage in their lives (Excerpt 7) [Author's emphasis].

This isiXhosa speaking student's view reveals her awareness that most South Africans speak English as an additional language. Here, English is perceived as an international language ("universal language") that socialises people into others' discourses. There is also an awareness of different language identities and the fact that people become immersed in new discourses as they interact and build networks with others. The role of interaction

in immersing people in new discourses could be explained in terms of the 'D' and 'd' discourses, showing how groups of people make use of language to recognise social relations and identities ("people from a foreign place"; "people in South Africa") within a particular context (Gee, 1996).

Finally, all the students acknowledged the key role of language as a means of communication; but some seemed to support the monolingual use of English in higher education for strengthening diversity. English was regarded as a language for inclusivity in terms of accommodating different cultural and linguistic groups, with other languages labelled as 'non-inclusive':

I do believe some universities are fair to everyone and those universities are diverse in both race and language, which plays an important role in having people communicate. The use of *non-inclusive languages* or *not universal language* does not only alienate the people that want to further their studies in that university but it also alienates the university from diversity and understanding of how different cultures work (Excerpt 8) [Author's emphasis].

While this response from an Afrikaans speaking student supports the role universities play in providing students with physical access, as opposed to epistemological access to education (Morrow, 2009), it assumes that all the students will have equal epistemological access to learning through English as LoLT. It perpetuates English's dominant status, perceived as a 'universal' language by speakers of other South African languages. This view could be attributed to the student's limited understanding of linguistic diversity and inclusion since a monolingual teaching and learning approach cannot be regarded as inclusive.

Below I focus on data that shows how student teachers experience the role of language in their learning at school and as prospective science teachers.

Science discourse and pedagogical practice

Some students mentioned the challenges they experienced as school learners and as student teachers concerning English as LoLT and science discourse. The difference between scientific language and everyday language was mentioned as a key challenge in science teaching and learning. Two isiXhosa speaking students had this to say:

As a learner at school I used to struggle with some of the science terms I would translate them in my own language. For example, energy and *amandla* ... and power ... they mean the same thing in Xhosa and Zulu ... so you have to be careful when you explain them to young children ... children get confused as they know the meaning of the terms in their own language (Excerpt 9).

I did Science up to Matric but I memorised some of the concepts, without understanding ... now it is not easy to explain to learners. Even now, I'm struggling with some of the big

science words. I have to use different methods to ensure that my children understand ... *sometimes I ask my peers to explain to me first* It's better now ... (Excerpt 10).

Excerpt 9 refers to the specialised scientific terminology, where words have different meanings in different languages and contexts (Mensah, 2007). The extract affirms that science has its own genres and that presentation of concepts in unfamiliar technical terms can impede learners' understanding of the content (Jarrett, 1999; Jones, 2000), leading to the perception that science is a difficult subject (Lemke, 1990). This view is consistent with Ogunniyi's (2019a) view that scientific language can be an epistemic obstacle when communicated through a LoLT other than the student's home language.

Excerpt 9 also reveals the student teacher's language identity (D), in that the student made use of her home language as a resource in learning. The student can be identified as an indigenous African language speaker since she referred to *Amandla* ['power, strength'], a Xhosa and Zulu concept. The student's response reveals aspects of the student's identity and socialisation and her struggle to make sense of scientific language and semantics (Lemke, 1990) at the school level. The student's lack of conceptual understanding of scientific terminology impacted her or his learning in higher education, while he or she displayed an awareness of the impact of misconceptions on children's science learning.

Excerpt 10 shows the impact of memorisation on the student teacher's understanding of the science concepts, which influences pedagogical knowledge (Chung-Parsons & Bailey, 2019). Teachers' histories, beliefs, attitudes and pedagogical practice shape their science identities, which influences the development of their learners' science knowledge and identities (Chung-Parsons & Bailey, 2019). This implies that strong science teacher identities are likely to develop positive science identities in their learners, while the opposite is also true.

The same excerpt also shows how the student capitalised on collaboration and apprenticeship ("sometimes I ask my peers to explain to me first"), two of the elements of Gee's (1996) theory. These elements denote that acquiring the 'd/D' discourses entail interaction with people who have experience of, or who have already mastered, the discourse(s). This type of interaction is associated with Vygotsky's concept of scaffolding and has implications for constructing identities (MacKay, 2007) as novice science teachers and second-language learners of English. It is also consistent with Wenger-Trayner's (2015) notion of 'community of practice', which involves collective learning in various activities for a common purpose.

One of the Afrikaans speaking students shared her classroom experience of how she struggled to explain certain concepts in English to isiXhosa home language learners due to her lack of competence in isiXhosa:

Ja, during teaching practice I wanted to explain the different types of energy to my class, but I could see that some did not understand at all I couldn't explain in Afrikaans,

Section IV | Blended pedagogies and knowledge sharing issues

so I asked one of the learners to explain in Xhosa and the problem was solved I felt bad that I couldn't do it as a teacher I learnt that I had to do demonstrations to make them understand ... (Excerpt 11).

This response identifies the student as an Afrikaans language speaker (*Ja/Yes*), and it shows the significance of language in communication for facilitating learning in the classroom. It also indicates the student teacher's awareness of the role of learners' home languages in their ability to learn scientific concepts. The learners were encouraged to draw on both the 'D' and 'd' discourses (Gee, 1996) for joint construction of science meaning. The student-teacher recognised learners' home languages as markers of their primary identity and cognitive and linguistic resources that facilitate meaningful learning in science.

Excerpt 11 illustrates the importance of an inclusive discourse for the student-teacher that affirms his identity (Gee, 1996) as a science teacher in a class with diverse languages. It also highlights the limitations of a monolingual approach, common in South African schools where the teachers do not speak their learners' languages (Prosper & Nomlomo, 2016), especially indigenous African languages. This could be attributed to the segregation of apartheid education that did not foster linguistic integration among different ethnic and language groups (Hartshorne, 1995).

In Excerpt 12 that follows, the same Afrikaans speaking student emphasised the importance of group work to facilitate science learning. The student-teacher was of the view that learners were able to scaffold each other's learning to understand the science content:

I like doing group work tasks because even the shy ones talk in the group ... They can *speak their own languages* and not feel small ... at the end you can see that they understand the work ... I also learn from these groups ... Our lecturer showed us how to use group work well (Excerpt 12) [Author's emphasis].

Group work engages learners in dialogue to perform tasks, enhancing their linguistic and cognitive development in science (Hewitt-Bradshaw, 2012). Excerpt 12 shows that the student teacher's inclusive approach facilitated an open discourse that allowed learners to "speak their own languages". This approach embraces diversity and affirms the learners' values and identities rather than only enforcing the dominant discourse's values (Gee, 1996). This approach also supports a learner-centred approach where interaction and collaboration are mediated through learners' own languages.

In addition, the excerpt shows an element of apprenticeship in the interaction between an experienced and less experienced individual in acquiring a particular discourse (Gee, 1996). The learners scaffolded each other's learning through group work; her lecturer scaffolded the student teacher's development through group work guidance as a pedagogical strategy. This excerpt highlights the relevance and application of community of practice as a resource in teacher training (Wenger-Trayner, 2015).

Discussion of findings

The study findings concerning the student teachers' experiences on the use of English as LoLT in science reveal important issues that pertain to the role of language in the development of teacher identity and science discourse.

Firstly, the findings alert us to pertinent issues that underpin language and identity construction in science education, consistent with the scholarly work conducted in the language field, teacher identity and practice.⁸ The findings show that student teachers' personal, historical, and language identities as school learners influenced their science education learning and interaction with school learners. This occurred as the student teachers negotiated pluralistic and multidimensional identities as English second-language learners, young professionals and novice science teachers (Avraamidou, 2016; Chung-Parsons & Bailey, 2019; Gee, 1996). They had to draw on their primary discourses linked to their vernaculars and identities and secondary discourses (d/D) to facilitate science learning (Gee, 1996). In other words, they used English as LoLT, their home languages and those of their learners to convey concepts using the complex scientific language. Given this, it may be argued that the student teachers' diverse experiences and language identities enabled them to explore various strategies to facilitate learners' access to scientific discourse. Therefore, the students' pluralistic identities should not be regarded as a deficit model feature in teacher training but rather a strength for inclusive pedagogies.

Secondly, the findings highlight the sociocultural and psychological views of teaching and learning, reflecting the student teachers' identities and self-esteem and confidence, some of the attributes of strong subject matter identity (Chung-Parsons & Bailey, 2019). In this study, some of the student teachers positioned themselves as having negative subject matter and science teacher identities due to their limited English proficiency as LoLT. This is a concern because negative teacher identities could negatively impact their competence and performance in the classroom (Airey & Linder, 2009). In addition, this finding seems to perpetuate the status quo with regard to learners' limited access to science, especially black learners from low socio-economic backgrounds in many South African schools (Campbell et al., 2007; Ogunniyi, 2019a). It is consistent with Nomlomo's (2007) view that English, as the main LoLT to non-mother-tongue speakers, continues to be a learning barrier from early childhood to tertiary education. This becomes critical for underprivileged black learners taught by teachers with limited English proficiency. They have gone through the same unequal South African education system where rote learning and memorisation are the most common strategies used to pass examinations. Therefore, it may be argued that English as LoLT remains an epistemological obstacle that perpetuates and reproduces

⁸ Chung-Parsons & Bailey, 2019; Avraamidou, 2016; Mahboob, 2016; Hewitt-Bradshaw, 2012.

inequality and social injustice for non-home language speakers of English, especially for those from marginalised groups.⁹

Thirdly, the above finding confirms the hegemonic status of English in education (Desai, 2016; Nomlomo, 2007; Prah, 2007). It also corroborates the view that English as LoLT is not critiqued as a barrier to the learning of African-language students, as is the case with some predominantly Afrikaans-speaking institutions in South Africa challenging the use of English as the only LoLT in higher education (Desai, 2016). This remains a contentious debate in South African higher education. Therefore, it is logical to assume that young teachers who do not speak English as a home language would experience difficulties with the science discourse (d/D) conveyed through the English medium. This limitation is likely to negatively impact their disciplinary and pedagogical knowledge central to teacher education knowledge (Nomlomo & Sosibo, 2016). Given this, student teachers could perceive themselves as inadequate in their academic and professional careers due to their lack of confidence in using English as LoLT in the classroom. Hence, many South African teachers whose instruction medium is English use code-switching as a coping strategy (Nomlomo, 2007).

Finally, the issue of apprenticeship (Vygotsky, 1978) within a community of practice (MacKay, 2007; Wenger-Trayner, 2015) is significant in this study. The findings show that peer support among student teachers enabled them to master the science discourse (d/D), despite the LoLT challenges, by exploring various teaching and learning strategies. This finding resonates with the sociocultural and dialogical perspectives of identity construction by science teachers (MacKay, 2007), whereby they actively interact and collaborate. In this study, the student teachers negotiated and constructed multiple identities using different languages, including their home languages, to enhance their disciplinary and pedagogical knowledge in science. Therefore, the findings highlight the sociocultural narrative, crucial in strengthening student teachers' personal and subject matter identities while enhancing their science discourse access. They also suggest that language is central to teacher identity construction (Leibowitz et al., 2005) and access to science discourse (Gee, 1996; Airey & Linder, 2009; Mensah, 2007).

Implications for the training of science teachers

The findings of this study have implications for language policy implementation and practice in basic and higher education. They indicate that student teachers' limited English proficiency impacts their teacher education knowledge acquisition, integrating theory and practice. This suggests a need for an inclusive and multilingual language policy and

⁹ Hewitt-Bradshaw, 2012; Chung-Parsons & Bailey, 2019; Essien, 2018; Hewitt-Bradshaw, 2012; Lemke, 1990; Mensah, 2007; Ogunniyi, 2019a.

pedagogical intervention that will include teacher educators and schoolteachers' in-service training on multilingual pedagogies to prepare student teachers for linguistically diverse classrooms. This calls for strategic collaboration between higher education institutions and schools, as communities of practice, to embrace language diversity for meaningful learning. This finding supports the principle of social justice and equity underpinning education in South Africa for students' equal epistemological access to learning (Morrow, 2009; Nomlomo & Katiya, 2018).

Secondly, the study findings indicate that English as LoLT and the science discourse constrain both the student teachers' and learners' epistemological access to scientific knowledge. This has implications for the science education curriculum that should incorporate language teaching across the curriculum and value multilingual education. This curriculum design could equip student teachers with an understanding of appropriate genres that could be used to facilitate the science discourse for effective teaching and learning in the classroom (Lemke, 1990).

The teacher-education science-curricular content should develop strong students' professional and subject matter identities (Chung-Parsons & Bailey, 2019). The curriculum content should have relevant theoretical and pedagogical knowledge to inspire young learners' interest in science. In other words, it should develop strong teacher identities in terms of competence in science content and practice (Chung-Parsons & Bailey, 2019). This entails capitalising on the student teachers' cultural and linguistic repertoires as resources to access scientific knowledge, translating into good pedagogical practice. This approach could encourage young learners to take the STEM subjects in higher school grades and tertiary education, thus developing their own science identities as science learners.

Finally, research on student teachers' language and science histories and how they define their identities as prospective science teachers would be useful. It could inform the science education curriculum's design and advance knowledge of how language affects student teachers' acquisition of different scientific education knowledge for multicultural and multilingual classrooms.

Conclusion

This chapter focusses on student teachers' experiences of using English as LoLT in their scientific learning as learners at school and constructing their identities as prospective science teachers in the senior phase (Grade 7-9). Guided by Gee's (1996) discourse theory, it explored the intersection between language, teacher identities and scientific discourses.

This study's findings are not generalisable due to the small sample but shed light on how student teachers' prior experiences as school learners shape their teacher identities, science

content understanding and pedagogical practice. They show an intersection between language, teacher identities and science discourse, which have implications for multilingual policy and pedagogies, curriculum design and collaboration for better performance and innovation in science teaching and learning.

English as LoLT is an ongoing and contentious debate in basic and higher education. This study's findings contribute to this debate, as many studies have been silent about the LoLT issue in teacher education and training. They also provoke us to question the language/s that have to be used in teacher education, given the increasing linguistic and cultural diversity in our classrooms, as well as the low number of learners who choose careers in STEM subjects, and the learners' low performance in these subjects, widely documented (Ogunniyi, 2019a).

These findings reflect the student teachers' understanding of the LoLT issue's complexity and their (non)readiness to teach in linguistically diverse classrooms. They challenge us to rethink our teacher education curriculum, especially science, with regard to languages and literacies that student teachers should be exposed to as part of multicultural education. The findings also open up new opportunities to explore teacher education knowledge construction in relation to the needs of the twenty-first-century classroom. It is necessary to explore further teacher identity and the role of language in science education in the wake of Covid 19 and other societal challenges.

References

- Agarkar, S.C. 2019. Influence of learning theories on science education. *Reson*, 24(8):847-859. <https://doi.org/10.1007/s12045-019-0848-7> [Accessed 19 January 2020].
- Airey, J. & Linder, C. 2009. A disciplinary discourse perspective on university science learning: Achieving fluency in a critical constellation of modes. *Journal of Research in Science Teaching*, 46(1):27-49. <https://doi.org/10.1002/tea.20265>
- Alexander, N. 2005. Towards mother tongue-based bilingual education: Summary of input given at a workshop hosted by the Eastern Cape Department of Education. *Multilingualism Action Group Newsletter*, 2:9.
- Alidou, H. 2003. Medium of instruction in post-colonial Africa. In: J.W. Tollefson & Tsui, A.B.M. (eds). *Medium of instruction policies: Which agenda? Whose agenda?* New York, NY: Routledge. <https://doi.org/10.4324/9781410609328>
- Avraamidou, L. (ed). 2016. *Studying science teacher identity: Theoretical, methodological and empirical explorations*. Rotterdam, Netherlands: Sense Publishers. <https://doi.org/10.1007/978-94-6300-379-7>
- Bell, J. 2010. *Doing your research project: A guide for first-time researchers in education, health and social science*. 5th Edition. Maidenhead, UK: Open University Press (McGraw-Hill Education). https://www.academia.edu/16705868/Judith_Bell_Doing_Your_Research_Project_Mc_Graw_Hill_Education_2010?auto=download
- Brock-Utne, B. 2005. "But English is the language of science and technology" - On the language of instruction in Africa - With a special look at Tanzania. In: Z. Birgit, Z. Brock-Utne, Z. Desai & M. Gorro (eds). *LOITASA Research in Progress*. Dar-es-Salaam, Tanzania: KAD Associates. 160-188.

- Campbell, G., Marx, J., Wilson, H., Perold, H. & Jooste, P. 2007. *Putting language into the mathematics and science equation*. Johannesburg, RSA: Zenex Foundation.
- Cardelle-Elawar, M. & Sanz de Acedo Lizarraga, M. 2010. Looking at teacher identity through self-regulation. *Psicothema*, 22(2):293-298.
- Chetty, R. 2012. The status of English in a multilingual South Africa: Gatekeeper or liberator? *Teaching English today: A project of the English Academy of Southern Africa*. <https://teachenglishtoday.org/index.php/2012/06/the-status-of-english-in-a-multilingual-south-africa/> [Accessed 6 June 2020].
- Chung-Parsons, R. & Bailey, J.M. 2019. The hierarchical (not fluid) nature of pre-service secondary science teachers' perceptions of their science identity. *Teaching and Teacher Education*, 78(February):39-48. <https://doi.org/10.1016/j.tate.2018.11.007>
- Desai, Z. 2016. Learning through the medium of English in multilingual South Africa: Enabling or disabling learners from low-income contexts? : Issues of quality, equity and social justice. *Comparative Education Journal*, 52(3):343-358. <https://doi.org/10.1080/03050068.2016.1185259>
- De Vos, A.S., Strydom, H., Fouché, C.B. & Delport, C.S.L. 2005. *Research at grassroots for the social sciences and human service professions*. 3rd Edition. Pretoria: Van Schaik.
- Essien, A. 2018. The role of language in the teaching and learning of early grade Mathematics: An 11-year account of research in Kenya, Malawi and South Africa. *African Journal of Research in Mathematics, Science and Technology Education*, 22(1):48-59. <https://doi.org/10.1080/18117295.2018.1434453>
- Gee, J.P. 1996. *Social linguistics and literacies: Ideology in discourses*. 2nd Edition. London, UK: Routledge.
- Gee, J.P. 1999. *An introduction to Discourse Analysis: Theory and Method*. 4th Edition. London: Routledge.
- Hartshorne, K. 1995. Language policy in African education: A background to the future. In: R. Mesthrie (ed). *Studies in South African sociolinguistics*. Cape Town: David Phillip.
- Helmenstine, A.M. 2019. Why mathematics is a language. *ThoughtCo: Mathematics*, June 27. <https://www.thoughtco.com/why-mathematics-is-a-language-4158142> [Accessed 6 June 2020].
- Hewitt-Bradshaw, I. 2012. Language issues in mathematics and science: An analysis of examiners' reports on students' performance in Caribbean secondary education certificate examinations (2010-2011). *Caribbean Curriculum*, 19:43-66. <https://journals.sta.uwi.edu/cc/index.asp?action=article&articleId=565> [Accessed 6 June 2020].
- Jarrett, D. 1999. *Teaching mathematics and science to English-language learners*. Portland, Oregon: Northwest Regional Educational Laboratory. <https://educationnorthwest.org/sites/default/files/11.99.pdf> [Accessed 6 June 2020].
- Jones, C. 2000. The role of language in the learning and teaching of science. In: M. Monk & J. Osborne (eds). *Good practice in science teaching: What research has to say*. Philadelphia, PA: Open University Press. 88-103.
- Leibowitz, B., Adendorff, H., Daniels, S., Loots, A., Nakasa, S., Ngxabazi, N., Van der Merwe, A. & De Venter, I. 2005. The relationship between identity, language and teaching and learning in higher education in South Africa. *Per Linguam*, 21(2):23-37. <https://doi.org/10.5785/21-2-74>
- Lemke, J.L. 1990. *Talking science: Language, learning, and values*. Norwood, NJ: Ablex.
- Leserth, K.A. 2013. Identity development among pre-service teacher candidates. *Graduate Theses and Dissertations*. PhD thesis. Iowa: Iowa State University. <https://lib.dr.iastate.edu/etd/13200> [Accessed 6 June 2020].
- MacKay, T. 2007. Inclusivity in English: Challenging the deficit model. *English Teachers' Association of NSW: About us: Positions on English: On inclusivity in English*. <https://www.englishteacher.com.au/about-us/positions-on-english/on-inclusivity-in-english> [Accessed 6 June 2020].

Section IV | Blended pedagogies and knowledge sharing issues

- Mahboob, A. 2016. Recognising the local in language teacher identity. In: G. Barkhuizen (ed). *Language teacher identity*. New York, NY: Routledge.
- Makoe, P. & McKinney, C. 2014. Linguistic ideologies in multilingual South African suburban schools. *Journal of Multilingual and Multicultural Development*, 35(7):658-673. <https://doi.org/10.1080/01434632.2014.908889>
- Mazrui, A.M. 2002. The English language in African education: Dependency and decolonisation. In: J.W. Tollefson (ed). *Language policies in education: Critical issues*. London, UK: Lawrence Erlbaum. 267-282.
- Mensah, F.M. 2007. Language in science education as a gatekeeper to learning, teaching and professional development. *Journal of Science Education*, 18(2):319-343. <https://doi.org/10.1007/s10972-007-9040-0>
- Mkhize, D. & Balfour, R. 2017. Language rights in education in South Africa. *South African Journal of Higher Education*, 31(6):133-150. <https://doi.org/10.20853/31-6-1633>
- Morrow, W. 2009. *Bounds of Democracy: Epistemological access in higher education*. Cape Town: HSRC Press.
- Msimanga, A., Denley, P. & Gumede, N. 2017. The pedagogical role of language in science teaching and learning in South Africa: A review of research 1990-2015. *African Journal of Research in Mathematics, Science and Technology Education*, 27(3):245-255. <https://doi.org/10.1080/18117295.2017.1367874>
- Muralidhar, S. 1991. The role of language in science education: Some reflections from Fiji. *Research in Science Education*, 21(December):253-262. <https://doi.org/10.1007/BF02360479>
- Nomlomo, V. 2007. Science teaching and learning through the medium of English and isiXhosa: A comparative study at two primary schools in the Western Cape. PhD thesis. Cape Town: University of the Western Cape.
- Nomlomo, V. & Katiya, M. 2018. Multilingualism and (bi)literacy development for epistemological access: Exploring students experience in the use of multilingual glossaries at a South African university. *Educational Research for Social Change*, 7(1):77-93. <https://doi.org/10.17159/2221-4070/2018/v7i1a6>
- Nomlomo, V. & Khuzwayo, B. 2019. Exploring teachers' experiences of mathematics, science and language. In: P. Iwuanyanwu & N.O. Vhonani (eds). *IKS as an agent of decolonisation and transformation for socio-economic development in Africa: Proceedings of the 5th International Conference of African Association for the Study of Indigenous Knowledge Systems*, University of Venda, Thohoyandou, October 23-25. 114-123.
- Nomlomo, V. & Mbekwa, M. 2013. Voices from the classroom: Teacher and learner perceptions on the use of the learners' home language in the teaching and learning of school mathematics and science. In: D.B. Napier & S. Majhanovich (eds). *Education, dominance and identity*. Rotterdam, Netherlands: Sense Publishers. 133-149. https://doi.org/10.1007/978-94-6209-125-2_9
- Nomlomo, V. & Sosibo, L. 2016. From theory to practice: Exploring beginner teachers' experiences of the depth and rigour of the Postgraduate Certificate in Education programme. *Perspectives in Education*, 34(1):199-215. <https://doi.org/10.18820/2519593X/pie.v34i1.14>
- Ogunniyi, M.M. 2019a. Indigenizing STEM education for equity and social justice. In: P. Iwuanyanwu & N.O. Vhonani (eds). *IKS as an agent of decolonisation and transformation for socio-economic development in Africa: Proceedings of the 5th International Conference of African Association for the Study of Indigenous Knowledge Systems*, University of Venda, Thohoyandou, October 23-25. 81-93.
- Ogunniyi, M.M. 2019b. Racism in mathematics, science and language education: The case of South Africa. In: P. Iwuanyanwu & N.O. Vhonani (eds). *IKS as an agent of decolonisation and transformation for socio-economic development in Africa: Proceedings of the 5th International Conference of African Association for the Study of Indigenous Knowledge Systems*, University of Venda, Thohoyandou, October 23-25. 94-103.

- Olsen, B. 2008. Introducing teacher identity and this volume. *Teacher Education Quarterly*, 35(3):3-6.
- Pennington, M.C. & Richards, J.C. 2016. Teacher identity in language teaching: Integrating personal, contextual and professional factors. *RELC Journal*, 47(1):5-23. <https://doi.org/10.1177/0033688216631219>
- Prah, K.K. 2007. *Challenges to the promotion of indigenous languages in South Africa*. Review commissioned by the Foundation for Human Rights in South Africa. Cape Town: The Centre for Advanced Studies of African Society. http://www.casas.co.za/FileAssets/NewsCast/misc/file/204_CV_Challenges%20to%20the%20Promotion%20of%20Indigenous%20Languages%20in%20Sou_.pdf [Accessed 6 June 2020].
- Prain, V. 2004. The role of language in science learning and literacy. In: C.S. Wallace, B.B. Hand & V. Prain. *Writing and learning in the science classroom. Science and technology library*, vol. 23. Dordrecht: Springer. https://doi.org/10.1007/978-1-4020-2018-6_4
- Probyn, M. 2006. Language and learning science in South Africa. *Language and Education*, 20(5):391-414. <https://doi.org/10.2167/le554.0>
- Prosper, A. & Nomlomo, V. 2016. Literacy for all? Using multilingual reading stories for literacy development in a grade one classroom in the Western Cape. *Per Linguam*, 32(3):79-94. <https://doi.org/10.5785/32-3-662>
- Rohandi, R. 2017. Teaching and Learning Science: Students' Perspectives. *International Journal of Indonesian Education and Teaching*, 1(1):16-23. <https://doi.org/10.24071/ijiet.2017.010103>
- Rus, C.L., Tomsa, A.R., Rebega, O.L. & Apostol, L. 2013. Teachers' professional identity: A content analysis. *Procedia - Social and Behavioural Sciences*, 78:315-319. <https://doi.org/10.1016/j.sbspro.2013.04.302>
- Søreide, G.E. 2007. *Narrative construction of teacher identity*. PhD thesis. Bergen, Norway: University of Bergen. <https://bora.uib.no/handle/1956/2532> [Accessed 6 June 2020].
- Tateo, L. 2012. What do you mean by "Teacher"? *Psychological Research on Teacher Professional Identity*, 24(2):344-354. <https://doi.org/10.1590/S0102-71822012000200012>
- Vygotsky, L.S. 1978. *Mind in society: The development of higher psychological processes*. Cambridge Mass: Harvard University Press.
- Webb, V. 2004. Language policy in post-apartheid South Africa. In: J.W. Tollefson & A.B.M. Tsui (eds). *Medium of instruction policies: Which agenda? Whose agenda?* New York, NY: Routledge. 217-240. <https://doi.org/10.4324/9781410609328>
- Wenger-Trayner, E. & Wenger-Trayner, B. 2015. Introduction to communities of practice: A brief overview of the concept and its uses. <https://wenger-trayner.com/introduction-to-communities-of-practice/> [Accessed 18 June 2020].