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Perceptions about the use of language in physical science classrooms: A discourse analysis

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The low enrolment, lack of interest, exacerbated by the general poor performance in physical science in South Africa paints a gloomy picture about the status of physical science in the country. Despite the fact that there might be other factors at play, one factor which cannot be ignored is the discourse about the use of language in the science classroom as viewed by physical science teachers. In the study reported on here a quantitative methodology was followed in which a closed-ended questionnaire survey was used as data collection tool. In the study we examined South African physical science teachers' perceptions about the language use in science classrooms, and the study was informed by the Vygotskian socio-cultural theory (SCT). The target population from which a sample size of 37 physical science teachers was systematically sampled was high school classroom teachers and learners in Grades 10, 11 and 12 in the Ngaka Modiri Molema district of the North West province of South Africa. The study revealed that physical science teachers encountered difficulties with meanings of non-technical words used in science context. The conclusion drawn was that many physical science teachers were not proficient in the discourse of the science classroom and this often compromised their effectiveness in the teaching and learning of science. The main difficulty was confusion in differentiating between technical and non-technical words and the lack of convincing explanations of meanings of these words in teaching and learning. Key among the recommendations of this study was the need to address teachers' challenges with regard to the language use and the implications thereof.

Keywords: discourse; non-technical words; proficiency; science classroom language; technical words

Introduction

The quality of South Africa's science and mathematics education is a cause for concern based on results of studies conducted by some international organisations. In the Trends in International Mathematics and Science Study (TIMSS), the mathematical and science proficiency of Grade 4 and Grade 8 learners are tested. Despite the fact that South Africa used Grade 5 and Grade 9 learners in this study instead of the prescribed grades in 2015, the performance of South African Grade 5 learners in mathematics and science was ranked 48 out of 49 countries while that of the Grade 9 learners was 39 out of 39 countries. In 2015, the Organisation for Economic Co-operation and Development (OECD) released a report ranking the education systems of 76 participant countries across the globe based on mathematics and science. From this study conducted by OECD, South Africa had the 75th worst education out of 76 countries (Roodt, 2018). This poor ranking of South Africa by two different independent international bodies is worrisome. Looking further, one finds that less than 0.5% of South African learners achieve university entrance qualifications in science and mathematics and many of those who do, do not graduate (Naidoo & Lewin, 1998). Mathematics and science are two gatekeeper subjects required to sustain a nation's economy (Ogunniyi, 2011). Based on the current situation, which includes the poor performance in physical science and low enrolment trends by South African learners, it is apparent that the concern about the low status of mathematics and science education in the country is justifiable. South Africa is desperately in need of suitably qualified engineers, science teachers, medical doctors, scientists and other scientifically oriented professionals. It is evident that this challenge will not be addressed soon if one considers the few learners who enrol for physical science from Grade 10 due to the perceived difficulty of the subject. The national enrolment statistics in physical science in South Africa revealed that from 2011 to 2014 the numbers were dropping as illustrated in Table 1 below.

Table 1 Physical science key indicators from 2011–2014 (Adapted from the Department of Basic Education [DBE], Republic of South Africa [RSA], 2015)

Year	Start of grade 12: Total enrolment	Science enrolment	% of matriculants enrolled for science	End of grade 12: Total exam takers	Science exam takers	% of exam takers writing science	Achieved at 30% and above	% at 30% and above
2011	534,498	184,052	34%	496,090	180,585	36.4%	96,441	53.4%
2012	551,837	182,126	33%	511,152	179,194	35.1%	109,918	61.3%
2013	576,490	187,109	32%	562,112	184,383	32.8%	124,206	67.4%
2014	550,127	171,549	31%	532,860	167,997	31.5%	103,348	61.5%

The national enrolment in physical science in South Africa has been dropping in recent years –it has dropped from 34% in 2011 to 31% in 2014. Similarly the number of learners who eventually write their physical science examination has dropped from 36.4% in 2011 to 31.5% in 2014.

With this study we sought to gain an understanding of physical science teachers' perceptions about meanings of non-science words when used in the science context in terms of their ability to differentiate between scientific and non-scientific words, herein referred to as technical and non-technical words respectively. The scientific knowledge is embedded in the words used in science and these words constitute the language of science; science teachers' language use is thus critical in the effective teaching and learning of science (Wellington & Osborne, 2001). This assertion implies the physical science teachers are also teachers of science language in addition to teaching science concepts in the classroom. It becomes apparent that science teachers need to understand and be proficient in the science language use for them to execute this additional role of being language teachers (Msimanga, 2013; Oyoo, 2012). In this study we recognise the role of the language used in the science classroom as critical for effective teaching and learning to take place. Therefore, the physical science teachers' perceptions about the use of language in the science classroom are important for effective teaching and learning in the discipline.

The language of science can be viewed as a tool that facilitates communication between the teacher and the learners in a science classroom (Scott, Mortimer & Ametller, 2011). Language is vital in bringing across new ideas, testing the learners' cognitive capacities, and replacing old ideas with new ones to bring about a new understanding in the learners' minds (Scott et al., 2011). This view is consistent with the pivotal role played by language in concept formation and development (Vygotsky, 1987). Accessing scientific knowledge in classrooms in any language is dependent on the teaching strategy used and the fact that the knowledge is codified in the words of whichever language is used in the learning of science. Thus, the physical science teachers' perceptions of the discourse about the use of language in the science classroom becomes critical (Oyoo, 2012).

It has generally been assumed that learners perform better in science once they have attained some proficiency in the language of learning and teaching (LoLT). However, this assumption has been put to the test by the common observation that not all learners who are proficient in the LoLT, including those who learn science in their home language, excel in science (Oyoo, 2012). The above assertion suggests that proficiency in the LoLT does play a part in excelling in science but does not guarantee success and excellence in science.

In this article we report om the findings of a study in which we investigated the perceptions of the physical science teachers about the use of language in the classroom. We also investigated the ability of the physical science teachers in differentiating between the technical (science) words and non-technical (non-science) words. The aim of this study was to unravel and explore the physical science teachers' perspectives on the use of language in the science classroom. This study was guided by the following research questions:

- How do physical science teachers in secondary schools interpret the discourse of the science classrooms?
- What are the physical science teachers' perceptions of the science classroom language use?
- What challenges do physical science teachers face in distinguishing technical words from non-technical words?
- What are the possible implications of physical science teachers' conceptions of the science classroom language use on the teaching and learning of science?

Hypothesis: There is no correlation between physical science teachers' understanding of the science classroom language and their ability to distinguish technical words from non-technical ones.

Oyoo (2011) argues that the attention that has been given to language issues in the learning of science has in the main been with regard to learners' proficiency in the language of instruction. A number of publications spanning four decades have described the problems of language in the learning of science (Oyoo, 2011). The findings reveal that science words pose a problem of unfamiliarity but learners were seen to be able to cope reasonably well. However, more challenging was the use in science of non-science words, familiar language in a highly specific or often changed and unfamiliar way where a simple word such as "pure" (meaning safe or clean) takes a new meaning when used in physical science (Johnstone & Selepeng, 2001). Learning through the medium of English poses problems for learners whose mother tongue is not English as is the case in the South African context where the majority of learners are second language speakers of English (Rollnick & Rutherford, 1996). This study will help to extend understanding of how the meanings of everyday words are misunderstood by learners when used in science context, regardless of their gender or linguistic background (Oyoo, 2012). In this study we sought to establish whether South African science teachers encountered difficulties with meanings of everyday words and science teachers' ability in distinguishing technical words from non-technical.

The study is expected to help address current issues of low enrolment and most probably poor results in physical science in South Africa. The national enrolment in physical science in South Africa has taken a downward trend in recent years (cf. Table 1) and this might mean that the country is likely to continue having shortages of engineers, medical doctors, science teachers and other scientifically oriented professionals. The future of any country, South Africa included, is dependent on the scientific and technological development as well as the quality of science education of that country (Ogunniyi, Jegede, Ogawa, Yandila & Oladele, 1995).

Physical science teachers' instructional language as a teaching tool has been out of general focus in international science education research (Oyoo, 2011). It becomes apparent that there is an urgent need for more research to focus on the manner in which physical science teachers use the language of instruction in classrooms by placing particular emphasis on the meanings of science and non-science words, which constitutes the language of science. Therefore, the need for this new focus in science education research is justified based on the need for teacher intervention in the learning of physical science and meanings of non-science words when used in scientific contexts.

In our opinion, the immediate beneficiaries of this study would be the science teachers and learners. There will be better communication between the physical science teachers and their learners, thus ensuring shared meaning of words used in science. For the teachers it will improve their science classroom language use, making it possible for learners to grasp science concepts better; and for the learners it should be manifested in their learning outcomes in physical science. However, in the long run, there will be more learners who are able to understand science concepts which might encourage more learners enrolling for science in schools than is happening currently.

Literature Review

Transnational studies have been conducted on learner difficulties with meanings of non-scientific words as used in the science classrooms after the pioneer study by Gardner (1972). Gardner in 1972 tested the understanding of 599 words on a sample of about 7,000 learners from 39 different schools across Australia and all the science learners who participated were English first language speakers (Farrell &Ventura, 1998). The results revealed that science learners had challenges in understanding meanings of non-scientific words when used in the science classroom contexts. The study by Gardner was replicated in other countries such as United Kingdom by Cassels and Johnstone (1980); Papua New Guinea by Farrell and Ventura (1998); Oyoo and Semeon (2015); Prophet and Towse (1999) and the results were very similar. The results revealed that science learners encounter difficulties with meanings of non-scientific words when used in science classroom contexts regardless of their gender, socio-economic and linguistic backgrounds. This explains why not all learners who are taught science in their mother tongue excel in the discipline.

South Africa, like many other African countries is a multilingual society with 12 official languages (Afrikaans and English – two former colonial languages and nine indigenous languages) as well as the recently added sign language, which are recognised as official languages by the Constitution of the Republic of South Africa 1996. However, in all secondary schools in South Africa, English and Afrikaans continue to be the languages of instruction despite the provisions made by the constitution which stipulate the right of all South African citizens to be taught in any of the 12 official languages. It appears that the influence of Afrikaans in South African schools is shrinking while that of English is expanding because English is viewed as a language of power and access (Probyn, 2006). English is the language of assessment, reading and writing, whereas the oral language of the school and classroom is their home language – particularly for many rural and township learners.

Physical science plays an increasingly vital role in the lives of all South Africans owing to its influence on technological and scientific development, which are necessary for the country's social well-being of its people and economic growth as stipulated in the new Curriculum and Assessment Policy Statement (CAPS) document (DBE, RSA, 2011). It becomes apparent that any study which seeks to improve the learners' performance in physical science in South Africa is significant. A number of factors are attributable to poor results in physical science and these include a lack of motivation amongst learners, lack of teaching resources and the use of outdated teaching methods (Kriek & Grayson, 2009). The presence of unqualified and under-qualified teachers, large classes, and low teacher effort have also exacerbated the lack of pedagogic content knowledge and skills by some teachers (Makgato & Mji, 2006; Van der Berg, Taylor, Gustafsson, Spaull & Armstrong, 2011). It thus becomes evident that there are many possible causes for poor performance in physical science in South Africa and the effect of the language of science, although rarely given much attention by many researchers, cannot be ignored (Oyoo, 2004). This is because everything to be known about physical science is all embedded in the words used in it, or the language of science, which comprises of technical (scientific) words and non-technical (non-scientific) words (Wellington & Osborne, 2001).

The components of the physical science classroom language

Physical science is a subject which comprises of chemistry and physics, in other words, two different subjects in one (DBE, RSA, 2011). The physical science classroom language is divided into two categories namely, the technical component (science words) and non-technical terms (non-science words). The technical component consists of science words specific to science subject, like atoms and elements associated with chemistry, and words like voltage, capacitance which are associated with physics (Oyoo, 2012). The non-technical component of science language is divided into three categories namely: logical connectives, meta-representational terms and non-technical (non-science) words used in a science context. Logical connectives are words or phrases that serve as links between sentences or between a concept and proposition, for example because, conversely and therefore (Oyoo, 2012). The second category is meta-representational terms which comprises of words or terms that signify thinking. The meta-representational terms are sub-divided into two namely: metalinguistic verbs and metacognitive verbs. Metalinguistic verbs are words that the place of the words "to say" such as suggest, define, explain and calculate, while metacognitive verbs are words which take the place of the verb "to think" such as analyse, calculate and deduce. The third category of the non-technical component comprises of non-technical (non-science) words used in a science context, which are words that have become part of the typical language of science subjects, but have different meanings in the everyday use of language such as diversity, reaction, open and closed (Oyoo, 2012).

In this study we focussed on the physical science teachers' understanding of meanings of non-science words when used in science context as well as their ability to differentiate between non-science words and science words. For example, the word "reaction" means the way one feels or behaves as a result of something that happens (Rundell, 2012:1172). However, when the same word "reaction" is used in science context, it describes what happens when two or more chemical substances are mixed. It is the way in which these non-science words acquire different meanings when used in science contexts as opposed to their everyday use which appears to be a challenge to both physical science learners and their teachers.

Theoretical Framework

The theoretical framework used as the analytical lens for this study was the Vygotskian SCT, which views language-mediated learning as a process where taking part in socially mediated activities is very important (Turuk, 2008). Mutekwe, Ndofirepi, Maphosa, Wadesango and Machingambi (2013), defined social constructivism as an epistemology that foregrounds the social construction of knowledge through interactive teaching and learning activities in the classroom. In other words, they view social constructivism as undergirding the importance of knowledge, including scientific knowledge, as a product co-constructed by the educators in meaningful interactions with learners through the use of science language (in this case) (Mutekwe et al., 2013).

The SCT assumes that learning in the second language context should be a collaborative process and should not be seen as an isolated individual effort where a learner works without receiving help from anyone (unmediated) (Turuk, 2008). The concept of mediation is quite central to the Vygotskian social-cultural perspective, where it implies that all teaching and learning situations need to be mediated or facilitated in one way or another (John-Steiner & Mahn, 1996). In the physical science classroom, the teacher plays the role of mediator or facilitator in the learners' acquisition of physical science content knowledge. The physical science teacher mostly interacts with learners through talking using the science language, using scientific models and equations, and conducting experiments. However, physical science learners are not limited to the mediator since they can supplement their science knowledge by using science textbooks. In this study we focused on physical science teachers' perceptions of the language used in the science classroom language, which cannot be isolated from teaching and learning in the discipline. This study was guided by the Vygotskian socio-cultural framework which emphasises the importance of talk (using a language) in social situations, as a necessary precursor to individual learning (Lantolf & Poehner, 2008). The socio-cultural views on learning emanates from the fact that during social interactions between the learners and their teacher, or among learners themselves, scientific knowledge is exchanged (Leach & Scott, 2003). In other words, it views science knowledge as being co-constructed between the learner and a mediator who ensures that the learner understands the science content being taught (Kozulin, 2002). Learning is a mediated process and is social in origin and only becomes individual after interaction through language use between the learner and the more knowledgeable other who can be a teacher or a competent peer (Lantolf & Poehner, 2008; Shabani, 2016; Vygotsky, 1987). In other words, the social-interactive occurring on the social plane is followed by the personal sense making of the learning process. It becomes apparent that language of science (which comprises of both technical and non-technical words) is pivotal as a means of mediation on both inter-mental plane (social plane) and intra-mental plane (in the learner's mind). Therefore, socio-cultural views of learning draw attention to how scientific knowledge is talked into existence on the social plane of the classroom, for showing how teachers control discourse on the social plane, and for considering learners' learning in response to teaching (Leach & Scott, 2003).

The socio-cultural theory views social interaction as the basis for learning and development. In other words, learning is a process of apprenticeship and internalisation in which skills and knowledge are transformed from the social level into the cognitive plane of the learner (Shabani, 2016). Mediation is a process which involves the use of learning tools such as material and psychological tools in assisting learners to understand their subject content better (Mutekwe, 2014). Thus, the concept of mediation is central to Vygotsky's socio-cultural perspective as such teaching and learning of scientific concepts should be mediated to help learners understand better. According to Vygotsky (1987) there are three forms of mediators, namely, psychological tools, material tools and human beings like the teacher or a more competent peer collaborator. The ultimate goal of all forms of mediation is to ensure that every function in the learner's cultural development happens twice; first, between people (inter-psychological) and then inside the learner (intra-psychological) or on the social level and later on the individual level (De Valenzuela, 2014). A mediator in this sense is not only limited to human beings such as a parent, a teacher, or a more competent peer, but can also include material tools and psychological tools.

Material tools are physical artefacts or teaching aids such as posters, slides, videos, charts, scientific models, which a teacher can use in the classroom to enhance learners' understanding of the scientific concepts being taught (Mutekwe, 2014). Psychological tools include gestures, semiotics and language which are employed during the mediation process (Shabani, 2016). This means that the use of language in the science classroom cannot be ignored as it plays a pivotal role as the main vehicle of thought (Lantolf & Poehner, 2008). According to Mutekwe (2014), the role of mediation in any learning situation including that of science is to scaffold and transform the learners' lower mental or cognitive functions to higher ones as the learner progresses from knowledge of one concept to the next. However, Mortimer and Scott (2003) argue that the meaning-making process in the learner's mind is further complicated by the fact that meanings of words, including non-technical words, acquire different meanings as the context of usage is changed. The Vygotskian socio-cultural approach to classroom promotes effectiveness in teaching and learning and it is for this reason that this study adopted the socio-cultural perspective as the theoretical framework.

Research Design and Methodology

In this empirical study the research design employed was a quantitative non-experimental type. It is important to note that generally speaking, quantitative research designs emphasise objectivity in measuring and describing the research phenomena (Maree & Pietersen, 2016). The quantitative research design maximises objectivity by using numbers, statistics, structure and control (McMillan & Schumacher, 2010). The non-experimental design used in this study was a survey, which was considered suitable on account of its ability to elicit objective quantitative data capable of providing suitable answers to the research questions posed (Maree & Pietersen, 2016). The survey made it easy to randomly sample physical science teachers who responded to the structured questionnaires voluntarily. Within the quantitative approach as used for this study, the data collected were coded into numerical forms and were, thereafter, subjected to statistical analysis to test for the stated hypothesis and significance of the data findings (Babbie, 2008).

Population and Sampling

The target population for the study comprised of all physical science teachers in the North West province, but it was going to be difficult and time-consuming to access all these teachers. Since most physical science teachers in South Africa are trained by the same institutions or universities, we decided to focus on those teachers who were easily accessible and willing to participate in the study. The sample of this study comprised of 37 physical science teachers of varied age, whose working experience ranged from 1 to 41 years. Fourteen were female teachers while 23 were male teachers. We chose secondary schools in one education district in the North West province of South Africa which was within 25 km radius from where we were staying. The reason for excluding primary schools is the fact that physical science in South Africa is only offered from Grades 10 to 12. A systematic sampling technique was employed in order to ensure that each and every sampling unit had an equal chance of being selected (Maree & Pietersen, 2016).

Ethical Considerations

To access the schools, we sought permission from the North West Department of Education. We also sought permission from the principals of secondary schools who then introduced us to the physical science teachers whom we asked to participate in the study. Most of the physical science teachers agreed to be part of the research. The issues of confidentiality, informed consent, right to privacy and right to withdraw from the study at any time were discussed and agreed to. All the participants signed consent forms to participate and none withdrew from the study prematurely.

Data Collection Procedures

A structured questionnaire survey method was employed to collect the data for this study. A questionnaire survey basically entails asking a sample of people from a population, a set of questions to describe their opinions, beliefs and experiences, and to possibly draw conclusions (Fowler, 2009). The use of a questionnaire survey was necessary because we were interested in collecting original data for describing and understanding a population too large to observe directly (Babbie, 2008). The quantitative methodology thus followed in which we use two questionnaires. The first was used to gather information on how physical science teachers conceptualise the physical science discourse in their classroom contexts. The second questionnaire investigated physical science teachers' ability to differentiate between technical and non-technical words. The first questionnaire (word test) was adopted and modified with permission from Oyoo (2004) and it comprised 30 multiple-choice questions, each with the target word underlined and with four alternatives to choose from (A, B, C and D). The purpose was to establish the extent to which the physical science teachers have challenges in understanding meanings of non-science words when used in science context or not. The second questionnaire comprised of open-ended questions on technical and non-technical words and was meant to establish if whether science teachers had problems in differentiating between the two aspects. Lee and Simon-Maeda (2006) support the use of such quantitative methods and logical aspects on the grounds that they are usually used to gather measurable data.

Analysis of Data

The structured questionnaire on the word test was statistically quantified and analysed for patterns and trends using the statistical package for the social sciences (SPSS). The relative difficulty in meaning of non-scientific words when used in science context was judged on the respective mean scores obtained per item. The second questionnaire helped to address the third research question of assessing the physical science teachers' ability to differentiate technical from non-technical words.

In the first questionnaire, words were grouped according to levels of difficulty based on the percentage score in the total sample as shown in the following criteria.

Table 2 Levels of difficulty of meanings of words from the study

Level	Percentage scores	Words
Level 0	100%	dehydrated, constant, conserve, concept
Level 1	90–99%	evacuate, negligible, source, function, limit, retard, linear, factors, valid, characteristic, generates
Level 2	80–89%	consecutive, displaces, fundamental, spontaneous, classify, effect, consistent, convention, estimate, disintegrate
Level 3	70–79%	contract, trace, sensitive
Level 4	60–69%	-
Level 5	50–59%	Prepare

The results summarised in Table 2 show that all the respondent teachers knew the meanings of the non-technical words "dehydrated, constant, conserve" and "concept" when used in a science context. The results reveal that, 21% to 30% of the teachers who participated did not know the meanings of the words: "contract", "trace" and "sensitive" when used in science context.

Table 3 Summary of the study results of technical and non-technical words

Technical words		Non-technical words				
Definition	Examples	Definition	Examples	Explanation of technical words	Explanation of non-technical words	Opinion on importance of explanation
cor – 11 incor – 22 blank – 4	cor – 18 incor – 15 blank – 4	cor – 13 incor – 20 blank – 4	cor – 24 incor – 9 blank – 4	explain – 29 don't explain – 8	explain – 20 don't explain – 15 sometimes – 1 not completed – 1	important – 28 not important – 9

Note. cor – correct definition, incor – incorrect definition, blank – the participant did not respond.

The results indicate that only 11 out of 37 physical science teachers who participated in the study were able to provide a correct definition of technical words, but only 18 gave the correct examples of technical words. On the other hand, 13 out of 37 teachers were able to give the correct definition of non-technical words and nine of them could not provide correct examples of non-technical words. Table 3 also indicates that four of the participant teachers did not complete the questionnaire for various reasons. Fifteen teachers did not explain meanings of non-technical words when used in science context. However, as indicated earlier, the socio-cultural perspective views learning in the classroom as occurring during social interactions – particularly between learners and their teacher. One might argue how scientific knowledge can effectively be exchanged between the learners and their teacher when the later struggles with the science language.

The results also revealed that eight out of 37 participant teachers did not take time to explain the meanings of technical (science) words while 15 did not explain the meanings of non-technical words during teaching. One of the teachers said that it would be a waste of time to explain meanings of non-science words because that was the responsibility duty of the English language teachers; his was to teach the science content. The majority of the participant teachers felt that it was important to explain meanings of both technical and non-technical words when teaching. However, their opinion of explaining meanings of all the words which make up the science language was particularly useful, especially considering how the meanings of words acquire different meanings as the context of usage changes.

Discussion of Findings

On a general level, the number of non-science words whose meanings were misunderstood by physical science teachers when used in science context demonstrated that the understanding of words in physical science was a matter which could be ignored. It was expected that the meaning of each non-science word used in a science context would be comprehended by all the physical science teachers. The expectation would seem justifiable, especially when one considers the fact that all the teachers were qualified and most of them had at least 5 years teaching experience in physical science. Out of the 30 non-science words used in the questionnaire, the following nine words emerged the most difficult for the physical science teachers: classify, fundamental, consecutive, effect, spontaneous, contract, trace, sensitive, and prepare. The meaning of the word "prepare" was the most misunderstood by the participants as shown in Figure 1.

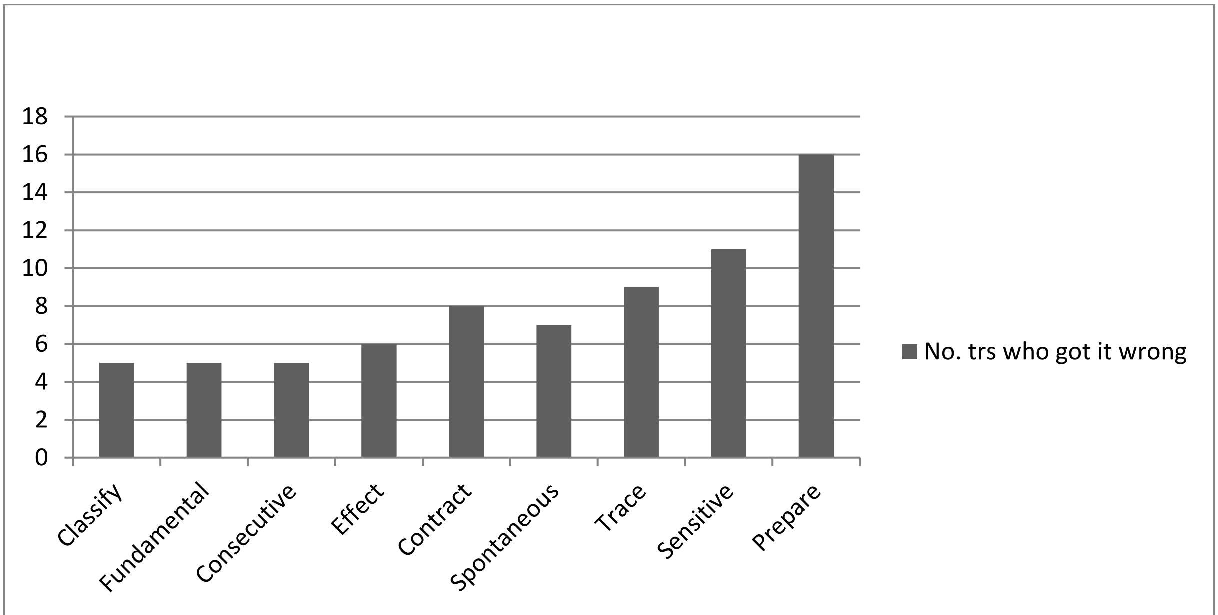

Figure 1 Difficult words for the science teachers from our study

The results reveal that physical science teachers have challenges in understanding meanings of non-science words when used in a science context. Results from previous studies indicate that science learners encounter difficulties with meanings of non-science words when used in a science context (Cassels & Johnstone, 1985; Farrell & Ventura, 1998; Gardner, 1972; Oyoo, 2004; Oyoo & Semeon, 2015). The participating physical science teachers lacked explicit awareness of how meanings of non-science words changed when used in a science context. The word "prepare" was used in the science context as follows:

If you were asked to describe how to <u>prepare</u> oxygen, it means that you are to say

a) the substances it is made of
b) what it is used for
c) how it behaves
d) how it is made

The expected response was "how it is made" (option D), but 16 of the 37 (43.2%) participant teachers got the meaning wrong and most of them chose "the substances it is made of" (option A). Another word whose meaning was problematic to a number of physical science teachers (29.7%) was "sensitive" which was used as follows:

The beam balance is a very <u>sensitive</u> instrument. This means that it

a) can be used to weigh very small things
b) can be used only by sensible people
c) is hard to understand how it works
d) gets spoilt very easily

The expected response to the above item was "can be used to weigh very small things" (option A), but a number of participant teachers chose "gets spoilt easily" (option D) and it would have been interesting to find out why they chose that option. The study revealed that it was not only physical science learners who had challenges with the meanings of non-science words when used in a science context, but also their teachers.

It was worrying to observe that physical science teachers experienced challenges with the language of the science classroom. One might then argue how these physical science teachers are able to communicate the scientific knowledge effectively to learners when they are not proficient in the discourse of the science classroom. How can the physical science teacher be expected to be a science language teacher when he or she struggles with the language? The fact that physical science teachers struggle with the language of science might be another reason why learners are not keen to enrol for physical science and might be a contributing factor to poor results in the subject.

The language of science is used as a tool that facilitates communication between the teacher and the learners (Scott et al., 2011). This communication is bound to be compromised if both the teachers and the learners are not proficient in the language of science. The failure by some teachers to explain meanings of both science and non-science words during teaching could be the reason why some learners struggle to understand science.

The major aim of transnational studies was to investigate whether or not the science learners encountered difficulties in understanding meanings of non-science words when used in a science context. The findings from these transnational studies revealed that challenges encountered by learners included a lack of the required comprehension, confusion between look-alike and sound-alike words, and selection of words whose meanings were opposites (Ali & Ismail, 2006; Cassels & Johnstone, 1985; Marshall & Gilmour, 1990; Oyoo, 2012; Prophet & Towse, 1999). These studies also found that the difficulties encountered by the participant learners were independent of gender, socio-economic and linguistic background. However, in our study the focus was on the physical science teachers and not the learners. The aim was to explore the perceptions of the physical science teachers on the classroom language use. The results reveal that teachers also encountered difficulties with the science classroom language, although they are the custodians of the science content. Most teachers, just like the science learners, failed to understand meanings of non-science words such as “prepare” and “sensitive” when used in a science context. One unanticipated finding was that 22 of the 37 participant teachers failed to define the meaning of technical words in science while 13 provided the correct definitions, of which nine provided incorrect examples of technical words. This demonstrates some confusion among the participants in differentiating science words from non-science words. One would question the effectiveness of such science teachers in teaching science content when they struggle with the language in which science concepts are taught.

We value the role played by the non-science words in the presentation of scientific content and ultimately the science classroom language in mediating learning in the science classroom. The results reveal that some of the participant physical science teachers could not provide the meaning of technical (science) words and non-technical (non-science) words and hence could not differentiate between the two. It becomes imperative that training institutions for physical science teachers should make them aware of the difficulties posed by non-science words when used in a science context. The importance of explaining technical and non-technical words should be incorporated into the curriculum of trainee physical science teachers. For practicing teachers, the district facilitators could arrange information-sharing forums or workshops where physical science teachers from different schools are made aware of the challenges and discuss the way forward. Learners could also be encouraged to explain science concepts in their own words as this would promote shared meaning between the teacher and the learners (Brock-Utne, 2015; Johnstone & Selepeng, 2001). We thus recommend that the graduate physical science teachers need to be appropriately and contextually proficient in the language of the science classroom. Once the teachers are made aware of this narrative, they will take time to explain meanings of both categories of words (technical and non-technical words) when teaching.

Conclusion

The aim of the study was to explore the perceptions of physical science teachers on the use of language in the science classroom. We can conclude that physical science teachers encountered difficulties in understanding meanings of non-science words when used in a science context. The findings have also revealed that participant teachers had challenges in distinguishing between non-technical and technical words, hence they failed to interpret the discourse of the science classroom. Based on the results from the foregoing discussion we came up with points which might have far reaching implications for future policy formulations in science teachers’ training institutions. Firstly, there is need to recognise the fact that it’s not enough for science teachers to be just proficient in the LoLT (English), but to also be proficient in the language of the science classroom, which comprises of science and non-science words. Secondly, science teachers should be made aware of the need to explain the meanings of all words which make up the science classroom language. Of particular concern, physical science teachers should take cognisance of the changeability of meanings of non-science words when used in science context as this has the potential to result in the creation of shared meaning between the teacher and the learners. More research is necessary to establish how physical science teachers can be equipped and become more proficient in the language of the science classroom so that they are able to discharge their duties diligently and effectively. As it stands, one might conclude that science teachers' lack of proficiency in the science language could be one of the factors why South African learners view physical science as a difficult subject and are not keen to enrol for the subject in Grade 10. However, there is a need for further research on the understanding of the meaning of non-science words and the understanding of logical connectives and meta-representational terms by science teachers.

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Authors' Contributions

Nasimu Semeon carried out the empirical data generation process and drafted the initial manuscript. Edmore Mutekwe conducted the data analysis and restructured the manuscript in accordance with the journal standards. Both authors reviewed the final manuscript.

Notes

i. This article is based on the doctoral thesis of Nasimu Semeon on the perceptions of the science classroom language use, which focused on the physical science teachers in the Ngaka Modiri Molema district of the North West province.

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References

Ali M & Ismail Z 2006. Comprehension level of non-technical terms in science: Are we ready for science in English? *Journal Pendidik dan Pendidikan*, 21:73–83. Available at https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1068.1836&rep=rep1&type=pdf. Accessed 8 February 2021.

Babbie E 2008. *The practice of social research*. Belmont, CA: Wadsworth, Cengage Learning.

Brock-Utne B 2015. Language, literacy and democracy in Africa. In L Makalela (ed). *New directions in language and literacy education for multilingual classrooms in Africa*. Cape Town, South Africa: The Centre for Advanced Studies of African Society (CASAS).

Cassels JRT & Johnstone AH 1980. *Understanding of non-technical words in science: A report of a research exercise*. London, England: Royal Society of Chemistry.

Cassels JRT & Johnstone AH 1985. *Words that matter in science: A report of a research exercise*. London, England: Royal Society of Chemistry.

Department of Basic Education, Republic of South Africa 2011. *Curriculum Assessment Policy Statement (CAPS)*. Available at: https://www.education.gov.za/Curriculum/CurriculumAssessmentPolicyStatements(CAPS).aspx. Accessed 20 September 2018.

Department of Basic Education, Republic of South Africa 2015. *2015 National Senior Certificate Examination Report*. Pretoria: Author. Available at http://www.ecexams.co.za/2015_Nov_Exam_Results/2015%20NSC%20Technical%20Report.pdf. Accessed 11 October 2018.

De Valenzuela JS 2014. Socio-cultural views on learning. In L Florian (ed). *The Sage handbook of special education* (Vol. 2). London, England: Sage.

Farrell MP & Ventura F 1998. Words and understanding in Physics. *Language and Education*, 12(4):243–253. https://doi.org/10.1080/09500789808666752

Fowler FJ Jr 2009. *Survey research methods* (4th ed). Thousand Oaks, CA: Sage.

Gardner PL 1972. *Words in science: An investigation of non-technical vocabulary difficulties amongst Form I, II, III, and IV science students in Victoria, a report*. Melbourne, Australia: The Australian Science Education Project.

John-Steiner V & Mahn H 1996. Socio-cultural approaches to learning and development: A Vygotskian framework. *Educational Psychologist*, 31(3-4):191–206. https://doi.org/10.1080/00461520.1996.9653266

Kozulin A 2002. Socio-cultural theory and mediated learning experience. *School Psychology International*, 23(1):7–35. https://doi.org/10.1177/01430343034302023001729

Kriek J & Grayson D 2009. A Holistic Professional Development model for South African physical science teachers. *South African Journal of Education*, 29(2):185–203. https://doi.org/10.15700/saje.v29n2a123

Johnstone AH & Selepeng D 2001. A language problem revisited. *Chemistry Education: Research and Practice in Europe*, 2(1):19–29. https://doi.org/10.1039/B0RP90028A

Lantolf JP & Poehner ME (eds.) 2008. *Socio-cultural theory and the teaching of second language*. London, England: Equinox Publishing.

Leach J & Scott P 2003. Individual and sociocultural views of learning in science education. *Science & Education*, 12:91–113. https://doi.org/10.1023/A:1022665519862

Lee E & Simon-Maeda A 2006. Racialized research identities in ESL/EFL research. *TESOL Quarterly*, 40(3):573–594. https://doi.org/10.2307/40264544

Makgato M & Mji A 2006. Factors associated with high school learners' performance: A spotlight on mathematics and physical sciences. *South African Journal of Education*, 26(2):253–266. Available at http://www.sajournalofeducation.co.za/index.php/saje/article/view/80. Accessed 4 February 2021.

Maree K & Pietersen J 2016. Surveys and the use of questionnaires. In K Maree (ed). *First steps in research* (2nd ed). Pretoria, South Africa: Van Schaik.

Marshall S & Gilmour M 1990. Problematic words and concepts in physics education: A study of Papua New Guinean students' comprehension of non-technical words used in science. *Physics Education*, 25(6):330. https://doi.org/10.1088/0031-9120/25/6/309

McMillan JH & Schumacher S 2010. *Research in education: Evidence-based inquiry* (7th ed). Boston, MA: Pearson.

Mortimer EF & Scott PH 2003. *Meaning making in secondary science classrooms*. Maidenhead, England: Open University Press.

Msimanga AS 2013. Talking science in South African high schools: Case studies of Grade 10-12 classes in Soweto. PhD thesis. Johannesburg, South Africa: University of the Witwatersrand. Available at http://wiredspace.wits.ac.za/bitstream/handle/10539/13341/Theisis%20Document.pdf?sequence=2&isAllowed=y. Accessed 4 February 2021.

Mutekwe E 2014. Improving learning equity through social constructivist approach to teaching and learning: Insights from the Vygotskian socio-cultural approach. *Mediterranean Journal of Social Sciences*, 5(27):1093–1099. Available at http://www.richtmann.org/journal/index.php/mjss/article/view/5184/5001. Accessed 2 February 2021.

Mutekwe E, Ndofirepi A, Maphosa C, Wadesango N & Machingambi S 2013. A SWOT analysis of the rise and pedagogical implications of the social constructivist epistemology in educational practice. *The Anthropologist*, 15(1):53–65. https://doi.org/10.1080/09720073.2013.11891292

Naidoo P & Lewin KM 1998. Policy and planning of physical science education in South Africa: Myths and realities. *Journal of Research in Science Teaching*, 35(7):729–744. https://doi.org/10.1002/(SICI)1098-2736(199809)35:7%3C729::AID-TEA4%3E3.0.CO;2-N

Ogunniyi MB 2011. The context of training teachers to implement a socially relevant science education in Africa. *African Journal of Research in Mathematics, Science and Technology Education*, 15(3):98–121. https://doi.org/10.1080/10288457.2011.10740721

Ogunniyi MB, Jegede OJ, Ogawa M, Yandila CD & Oladele FK 1995. Nature of worldview presuppositions among science teachers in Botswana, Indonesia, Japan, Nigeria and the Philippines. *Journal of Research in Science Teaching*, 32(8):817–831. https://doi.org/10.1002/tea.3660320805

Oyoo S 2011. Foreign languages in African science classrooms: Perspectives on and approaches to language use during teaching. In R Aluko (ed). *Distance Education and Teachers' Training in Africa (DETA) Conference Proceedings 2011*. Maputo, Mozambique: Eduardo Mondlane University. https://doi.org/10.35293/tetfle.vi.14

Oyoo SO 2004. Effective teaching of science: The impact of physics teachers' classroom language. PhD thesis. Melbourne, Australia: Monash University.

Oyoo SO 2012. Language in science classrooms: An analysis of Physics teachers' use of and beliefs about language. *Research in Science Education*, 42(5):849–873. https://doi.org/10.1007/s11165-011-9228-3

Oyoo SO & Semeon N 2015. The place of proficiency in the language of instruction: Grade 12 physical science learner's encounter with everyday words in science context. In L Makalela (ed). *New directions in language and literacy education for multilingual classrooms in Africa*. Cape Town, South Africa: The Centre for Advanced Studies of African Society (CASAS).

Probyn M 2006. Language and learning science in South Africa. *Language and Education*, 20(5):391–414. https://doi.org/10.2167/le554.0

Prophet B & Towse P 1999. Pupils' understanding of some non-technical words in science. *School Science Review*, 81(295):79–86.

Republic of South Africa 1996. *The Constitution of the Republic of South Africa (Act 108 of 1996)*. Pretoria: Government Printer.

Rollnick M & Rutherford M 1996. The use of mother tongue and English in the learning and expression of science concepts. A classroom-based study. *International Journal of Science Education*, 18(1):91–103. https://doi.org/10.1080/0950069960180108

Roodt M 2018. *The South African education crisis: Giving power back to parents*. Johannesburg, South Africa: South African Institute of Race Relations (IRR). Available at https://irr.org.za/reports/occasional-reports/files/the-south-african-education-crisis-31-05-2018.pdf. Accessed 11 February 2021.

Rundell M (ed.) 2012. *Macmillan English dictionary for advanced learners*. Oxford, England: Macmillan Education.

Scott P, Mortimer E & Ametller J 2011. Pedagogical link-making: A fundamental aspect of teaching and learning scientific conceptual knowledge. *Studies in Science Education*, 47(1):3–36. https://doi.org/10.1080/03057267.2011.549619

Shabani K 2016. Applications of Vygotsky's socio-cultural approach for teachers' professional development. *Journal of Cogent Education*, 3(1):1252177. https://doi.org/10.1080/2331186X.2016.1252177

Turuk MC 2008. The relevance and implications of Vygotsky's sociocultural theory in the second language classroom. *ARECLS*, 5:244–262. Available at https://d1wqtxts1xzle7.cloudfront.net/37336864/vygotsky.pdf?1429294595=&response-content-disposition=inline%3B+filename%3DTHE_RELEVANCE_AND_IMPLICATIONS_OF_VYGOTS.pdf&Expires=1611906732&Signature=ZGLbA12GLRdiSBuQOZ7VRn8R6AGkLC95ZwOG6-mtD7ptHXHFUDfPFirth9nY9AH3CaBoEI0VUyfnJr3hLkVp1G4bzX9Aulvcut-QzuWOnCQxB8VyqUNQfApVuM5BVIHDWGYQ7ZO599hfnj9a5QxhTUHQ6odgE4NrpXk3baxWQ2tWx8so0xhfpKs5td2-lGa-SthfwWgJEM~A9VjtnydpvSexsbvQG76rUPGmEwuR6HqCoUSNgy~zqH0Uck00xh-KbpFuT-YRtVJ85gV63fvksrDkCjk2Ir7CE34-WXjg4fGJYdwIPvjLAzCT~zBRhcUoaSo0CSzyEaE5xCldmECbsA__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA. Accessed 30 January 2021.

Van der Berg S, Taylor S, Gustafsson M, Spaull N & Armstrong P 2011. *Improving education quality in South Africa* (Report for the National Planning Commission). Stellenbosch, South Africa: Department of Economics, University of Stellenbosch. Available at https://resep.sun.ac.za/wp-

content/uploads/2017/10/2011-Report-for-NPC.pdf. Accessed 8 February 2021.
Vygotsky L 1987. *Thought and language*. Cambridge, MA: MIT Press.
Wellington J & Osborne J 2001. *Language and literacy in science education*. Buckingham, England: Open University Press.