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PHYSICAL SCIENCE TEACHERS' USE OF READING STRATEGIES IN A SOUTH AFRICAN CONTEXT

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ABSTRACT

Teaching in global multilingual societies requires a change of instruction concerning reading comprehension, as many learners are not instructed in their home language. Reading comprehension skills are lacking in South Africa and are discernible in subjects like physical sciences, where the text requires high levels of cognitive thinking. This study focused on improving reading comprehension using strategies like vocabulary, syntactical awareness, and text recognition, among others. An interpretative qualitative approach was chosen to determine to which extent reading strategies are used and taught in the physical sciences classroom. Semi-structured interviews and non-participant teacher observations were conducted to determine the participants' knowledge of and ability and skill in using reading strategies. The study found that the use of reading strategies in physical sciences classrooms was limited, and the participants (physical sciences teachers) were unable to integrate many strategies to assist with reading comprehension.

KEYWORDS: Reading strategies, physical sciences, reading comprehension, language teaching, simple view of reading, transactional theory

INTRODUCTION

The global demand for professionals who are proficient in English has increased due to the need for a lingua franca (Bayyurt et al., 2019: 185). In many countries, indigenous languages are not used in teaching and learning, which is also the case for South African learners. Studies like the Progress in International Reading Literacy (PIRLS) explore how using English as a medium of instruction affects learners who are not taught in their home languages (Mthimkhulu, Roux, & Mihai 2024: 2). Similarly, the Trends in International Mathematics and Science Studies (TIMSS) evaluate learners' proficiency in specific grades in various countries in science and mathematics (Reddy, Juan, Isdale & Fongwa, 2019: 170). South Africa's dismal performance in these international studies necessitates research into the possible causes of such poor performances. Research by Howie et al. (2017) finds that South African learners' basic knowledge of science and mathematics does not meet the minimum global standard. Furthermore, the latest PIRLS results for 2021 show that South African learners in Grades 4 and 6 achieve a lower-than-average score because they are unable to read with comprehension. This inability to read with understanding becomes a major barrier to learning, not only in the language classroom but even more so in cognitively challenging subjects like physical sciences. Consequently, learners are unable to grasp the content fully and are therefore unable to assimilate knowledge effectively.

Unfortunately, many content teachers of physical sciences, for example, assume that learners can read with understanding and, thus, do not focus on teaching the language of their disciplines or assisting students to read for meaning (Swart, 2021: 45). The curriculum for physical sciences in the FET phase, which entails Grade 10–12 learners in South Africa, is loaded with content, placing immense pressure on teachers to cover all the required content for a specific grade. Teachers are often more concerned with completing the curriculum and yielding the desired results than with the need for teaching reading/language in their classrooms (Ness, 2016).

South Africa (like many other countries with more than one official language) has 12 official languages, and English is mostly used as the LoLT. Learners who are taught through the medium of English instead of their home languages may experience difficulty with comprehending and making meaning of texts. Consequently, learners whose home language is not English not only have the added task of learning a language (English) but also the subject-specific language, for example, science literacy. Mavuru and Ramnarain (2019: 4) indicate that scientific language is complex, abstract, and very specialised. Learners are expected to understand content-specific language to assimilate the knowledge needed for comprehension.

Reading Strategy Instruction (McEwan, 2004) can aid learners in their understanding of academic subject content and is not limited to the language classroom, as these strategies can also be used in the content classroom. Academic text depends on the extraction of knowledge from a variety of texts using reading strategies (Swart, 2021: 29). Science teachers must combine subject content and language teaching to promote understanding, especially in cases where the medium of instruction is not the learners' home languages (Swart, 2021: 26). This study focused on how reading strategies can be used in the physical sciences classroom to aid the comprehension of a variety of texts used in the discipline, for instance, chemical equations, schematic diagrams such as an electrical circuit diagram, and experiments.

The study specifically explored how reading strategies could be used in physical sciences teaching in the FET phase in South African classrooms where English, as an additional language, is used as the medium of instruction and whether these strategies could be taught explicitly. Teaching learners how to use reading strategies could enable them to deconstruct a text to aid comprehension. Deconstructing a text to find key information and deciphering the main ideas in the text allow learners to become active readers who can identify patterns in different texts by analysing the different components of the text (Kosimov, 2022: 30). An example of this is when learners must identify and interpret data either given to them in graph form or when learners are required to select particular information to represent in a graph. Masharipova and Mizell (2021: 40) argue that learners should be encouraged to use reading strategies in the process of learning, which might lead to them using these strategies independently.

This study focused on reading strategies (Table 1), as suggested by McEwan (2004). McEwan's (2004) reading strategies entail an analytical and structured approach to teaching reading strategies. According to Lu, Valcke and Van Keer (2021: 2176), the strategies suggested by McEwan (2004) offer an integration of cognitive strategies, such as activating prior knowledge, inferring what is not explicitly written, and monitoring/clarifying in reading.

Table 1 Strategies for effective reading

Activating	Using prior knowledge and experiences to construct meaning from text.
Inferring	Bringing together different parts of the text to construct meaning.
Clarifying	Monitoring reading techniques during and after reading to determine comprehension of the text.
Questioning	Engaging with the text through a variety of questions to derive meaning from the text.
Selecting	Using different sources and selecting relevant information to clarify misunderstandings, solve problems or gather information.
Summarising	Restating the meaning of the text by using your own words.
Visualising	Constructing a mental image of the text to facilitate meaning.

Source: McEwan (2004: 8)

The research question guiding this study is: How can reading strategies be used in a second language classroom to foster learning in physical sciences?

THEORETICAL FRAMEWORK

Theoretically, this study is underpinned by Cummins's work on two aspects of language proficiency: Basic Interpersonal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP) (Cummins, 2017). According to Cummins (2017), learners' ability to read with comprehension in the target language, in this case, the additional language, as the medium of instruction (LoLT), is determined by Basic Interpersonal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP). Cummins (2017: 73) argues that the interaction between BICS and CALP is important for subject comprehension. Consequently, teachers should not only focus on the development of BICS but also CALP. The development of CALP is more challenging as it requires cognitive ability, especially as learners progress through each grade (Swart, 2021: 18). In the context of this study, CALP is linked to scientific literacy (SL), which refers to how learners process scientific facts and concepts and interprets scientific data (Kelp, McCartney, Sarvary, Schaffer & Wolyniak, 2023). Cao, Zhang and Xin (2024) highlight the relationship between reading engagement and scientific literacy, postulating that reading engagement in the science classroom is the entry point to gaining knowledge and understanding. The advancement of reading skills in the science classroom allows for the advancement of scientific literacy and for the preparation of learners to deal effectively with assessments in the FET phase that demand higher-order cognitive skills to reach set outcomes (Swart, 2021: 21). On the other hand, learners with poor reading abilities struggle to understand and process subject content (Fang, 2017: 494). In other words, learners who lack scientific literacy would be unable to demonstrate understanding and can expect to perform poorly in assessments (Bharuthram & Clarence, 2015: 43).

LITERATURE REVIEW

This section provides a brief overview of literacy in science education. Hurd (1958: 19) coined the term scientific literacy and regards it as an understanding of science and how it applies to social experience. Laugksch (2000: 3) maintains that scientific literacy “was coined in the late 1950s” and one can therefore argue that it is not a novel educational concept but one that has garnered much interest over the years. Although there is no clear definition of scientific literacy, it is generally accepted as the main goal of science teaching (Aragão & Marcondes, 2018: 1). The authors further argue that scientific literacy is defined based on the focus and purpose of science teaching. One must keep in mind that scientific literacy entails not only the written, numerical and digital literacy needed for comprehending science but also literacy demands beyond mere inquiry skills, which entails reading, writing, speaking about and listening to a variety of texts.

Norris and Phillips (2003: 224) capture the twofold sense of science literacy. They mention that in the English language, literacy refers to one’s ability to read and write, as well as “knowledgeability, learning, and education”. This sentiment is echoed by Pearson, Moje and Greenleaf (2010: 459), who maintain that there has been an urgent call for science education to change over the past 20 years, yet this call for change has many, and at times, contradicting meanings. Pearson et al. (2010) identify two main understandings of scientific literacy: The first focuses on how familiar one is with the natural world, key concepts, and principles in science, while the other focuses on connections with the language of science, and how these concepts are used in various text types. The latter also concerns how students develop skills in reading and writing and the ability to think critically about the language used in, for example, physical sciences texts (Pearson et al., 2010: 459). The argument is that to understand concepts and gain comprehension in subjects like physical science, the learner needs to engage and connect with the text.

Norris and Phillips (2003) further argue that reading and writing do not only have a functional relationship with science—seen as instruments to store and transmit science content, but rather also have an integral relationship with reading and writing—seen as essential skills in science. The researchers believe that reading comprehension skills are necessary when learners have to evaluate scientific claims and arguments critically and when they have to engage in informed decision-making regarding scientific issues.

It might be useful to examine the relationship between science and language over time. Mattheissen (1998) posits that the arrival of cognitive sciences, the belief that behaviourist stimulus–response reinforcement had limitations and that the neglect of the social element of learning had much to do with the development of understanding literacy in science. Yore, Gay, Bisanz and Hand (2003: 697–698) mention that studies during the period of 1978–1993 focused on aspects such as the content and style of textbooks, students’ reading skills, and teachers’ usage of textbooks as if these were separate parts of the reading process. The researchers further say that (fortunately) reading has changed from mostly text-driven models to models focusing on the reader and, eventually, to models focusing on readers’ interaction with texts (Yore et al., 2003: 698). The implication of this is that texts that allow for better interaction between the learner and the text result in the learner becoming a more active reader (Swart, 2021: 12). Constructivist theories in education compelled science education researchers to revisit their initial beliefs about the function of texts, namely assuming that texts by and of themselves bear all the meaning. Constructivist theories insist that readers construct their own knowledge based on prior experience and are actively engaged in knowledge-making. This notion gave rise to more interactive theories of reading focusing on the relationship among texts, readers and authors.

The next section explains the theory of reading that underpinned this research.

THE SIMPLE VIEW OF READING IN CONJUNCTION WITH THE TRANSACTIONAL THEORY OF READING

This research is informed by the simple view of reading in conjunction with the transactional theory of reading. The simple view of reading (SVR) entails the formula of "Decoding (D) x Language Comprehension (LC) = Reading Comprehension (RC)" (Gough & Tunmer, 1986). Both these domains are essential to reading for meaning; a lack of either decoding or linguistic comprehension will result in reading without meaning. This view of reading is relevant to all contexts, including science education. Learners need to be able to decode words as part of the reading process. However, decoding as such does not mean that learners necessarily understand what they are reading. Learners may be able to decode perfectly without drawing any meaning from texts, and learners who struggle to decode may expend all their energy on the decoding process, which, in turn, influences fluency and affects comprehension. Comprehension might be enhanced by focusing on reading strategies and teachers either by explicitly teaching these or modelling these to learners. Norris and Phillips (2003: 229) argue that the reader's background knowledge, their ability to make meaning outside the text, construct their own meaning, place texts in context, and understand the author's intention are important in the reading process. This echoes the tenets of transactional theory through which readers construct meaning rather than identifying a meaning which is supposedly inherent within the text (Rosenblatt, 1938/1995). In her seminal work, *The Reader, The Text, The Poem*, Rosenblatt (1978) reacted to an emphasis placed on "the work itself", which was advocated by new criticism theory. The advocates of new criticism maintained that meaning could be extracted through a close reading of a text. However, Rosenblatt emphasises the transactional relationship of reading between reader and text. She calls this transaction an event which is not fixed in meaning but may be revised based on new experiences and understanding (Rosenblatt, 1978/1994: 16–17). The transactional theory is relevant to this research as reading in the physical sciences classroom is not a simple matter of decoding text or learners being inducted into certain interpretations by the teacher but, rather, requires the active participation of the learner in the reading process for them to make meaning of texts.

METHODOLOGY

This interpretative qualitative study employed a single case study consisting of three physical sciences teachers employed at one public school in Gauteng province, South Africa. The design was appropriate for this study as it entailed an in-depth analysis of a small, non-randomised sample. The school was chosen based on the concerns of the target group (physical science teachers), who shared these with the researcher after analysing the final results comprising the School-Based Assessment SBA and the exam marks of learners in physical sciences from the previous years. Participants were selected because they teach physical sciences to Grade 10–12 learners in the FET phase. This phase was chosen because of poor results in physical sciences, as seen in South Africa's performance in the 2019 TIMMS. The performance of Grade 8 learners in the study showed that South Africa achieved a score of 370 points, which is far below the lowest benchmark, which is 400 points (TIMMS, 2019). The poor performance of learners in Grade 8 negatively affects such learners who choose physical sciences as a subject in the FET phase, as the basic knowledge required for science is limited. The requirement for inclusion in the study was for the three participants to be physical sciences teachers of Grade 10–12 learners in the FET phase. The total number of lessons observed was 15—five per teacher.

Table 2 Biographical information of participants

Participant	Age	Gender	Teaching experience	Linguistic ability (per participant)	Linguistic ability (per observation)
A	29	F	6	Very Good	Good
B	51	F	17	Good	Good
C	43	M	12	Good	Good

Data collection commenced by observing the participants while teaching physical sciences during face-to-face sessions. An observation schedule (See Addendum A) was used to document the strategy the participant used, whether or not the participant explicitly taught the strategy to learners and linked different strategies. For example, Participant A used inference, but the strategy was not explicitly taught to the learners, and the teacher asked no probing questions. The observation schedule also included vocabulary (word explanation vs defining, word attacking and vocabulary repair) to ascertain if the participants assisted learners with issues that might occur due to gaps in their vocabularies. The observation schedule was self-designed to include specific elements relating to teaching and using the reading strategies we wished to observe, for example, activation of prior knowledge, inference, and questioning, among others.

Semi-structured interviews (See Addendum B) of approximately 90 minutes each were conducted with the three participants. The 15 questions asked during the interviews allowed for open-ended answers, which also led to follow-up questions that yielded more in-depth data as a result of open-ended responses. The questions were asked in a specific order, starting with each participant's experience in teaching physical sciences. The questions became more specific regarding teaching language, specifically reading, in their classrooms. The interviews focused on establishing whether the participants possessed the required knowledge of language structures to teach these structures in their classrooms to improve reading comprehension. An example of a question is: Do you think it is important for you to be a language instructor in your classroom? This question revealed the participant's attitude towards incorporating language into their teaching. The interview questions were designed to determine whether or not the participants were aware of reading strategies, saw the need for language to help with comprehension in their subjects and were adequately prepared to teach language in a content class. During the interviews, we also probed participants on their preparedness, confidence levels and attitude insofar as teaching language and reading strategies.

The study conducted document analysis of two official documents, namely the Curriculum and Assessment Policy Statement (CAPS) for physical sciences, Grade 10–12 in the FET Phase and the DBE's Manual for Teaching English Across the Curriculum, which yielded the rich data required for a single case study. Bowen (2009) argues that the data yielded during a document analysis often group main themes, categories and examples. Consequently, the document analysis in this study focused specifically on the extent to which these documents guide and support teachers in helping learners with reading in the physical sciences classroom. The study analysed two lesson plans of teachers teaching physical sciences in the FET phase to establish the extent to which the lessons were structured to allow for the teaching of language and reading strategies. The two lessons were analysed separately from the lesson observations. The rationale for this was to determine whether the teachers' planning differed significantly from the execution of lessons. We were able to see the development of the lesson and the main focus of each phase of the lesson. The results of the lesson plan analysis were shared during the interviews when participants were asked how they implemented language teaching if there was no mention of it in the lesson plans. These lesson plans also provided information on the amount of time spent on teaching language and reading in the physical sciences classroom, as they indicated no clear time allocations for teaching language and reading during the lessons. Cognisance should be taken that language education is not part of the prescribed physical science curriculum or one of its aims; it is merely mentioned that language skills in reading and writing should be developed in physical sciences.

The data were coded using a hands-on approach because of the relatively small sample size, which aided the organisation of the data into different themes. The document analysis identified references to language to ascertain how the documents assist teachers with teaching language in their classes. All data were organised into themes related to reading strategies and then represented in the form of tables and figures. One identified theme was the implementation of reading strategies by the participants during their lessons. The observations and interviews were summarised separately to determine if what the participants had said aligned with what was seen in the classes during the observations.

Ethical clearance for the study was granted by the ethics committee of the North-West University's EMELTEN-REC ethics committee. The Gauteng Department of Education also granted permission for the study to be conducted. All participants gave informed consent prior to the commencement of the study.

RESULTS

The analysis of the data collected through the observations, documents and interviews provided clear insight into the use of the three participants' reading strategies in the physical sciences classroom. In this paper, each instrument is discussed separately as part of the data analysis. Thereafter, the findings are integrated as they reflect similar themes. The data revealed to what extent reading strategies were used in the physical sciences classrooms, as well as the participants' attitudes towards scaffolding language in their classrooms. Furthermore, the data revealed how prepared these participants felt to integrate language teaching and content in their lessons to aid learner comprehension.

Observations

The focus of the observations of five lessons per participant was to establish the use of reading strategies in the physical sciences classroom. Some reading strategies, like the activation of prior knowledge, were used, but there was no overt teaching of these strategies in the classroom. The participants created the link for the learners by giving a verbal summary of the previous section instead of teaching the learners how to establish a link for themselves. The observation schedule utilised McEwan's (add the date) reading strategies to ascertain how reading comprehension is taught in the classes observed. The findings for each participant are discussed in terms of 1) implementation and teaching of reading strategies, 2) teaching of language concepts and structures, and 3) the proficiency of participants in using English as the medium of instruction.

Implementation and teaching of reading strategies

Throughout the observations, the participants used a variety of reading strategies. The use of the different reading strategies was recorded by using an observation schedule based on the reading strategies suggested by McEwan (2007). The study noted that certain strategies were favoured over others. Figure 1 below reflects the participants' use of reading strategies.

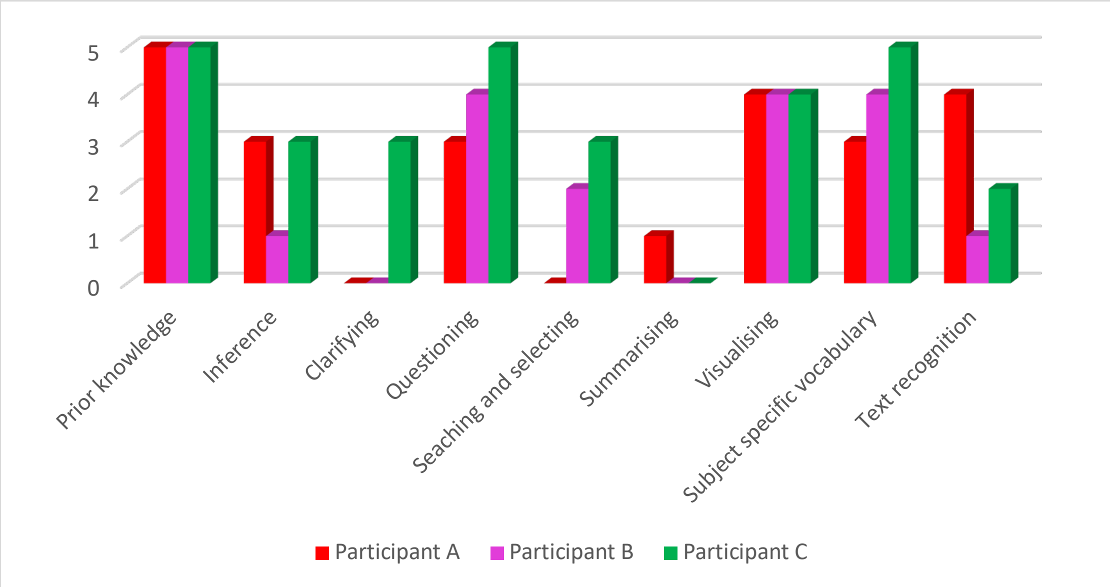

Fig. 1 The frequency of reading strategies during the observed lessons

The participants predominantly used the activation of prior knowledge. They also used subject-specific vocabulary that had been taught in prior lessons; for example, the word "vector" was used. Not only did the participants refer to learners' prior knowledge, but they also used it as a foundation to help learners with the acquisition of new knowledge. Unfortunately, the participants assumed that the learners had already mastered the previous content, although some learners could not apply prior knowledge to comprehend the content being taught. In general, the learners were able to use prior knowledge to solve problems. The participants also used visualisation effectively by providing a link between the content and real-world scenarios. An example of this was when one of the participants asked learners to imagine being on an escalator; learners were then asked to comment on the different forces present when using the escalator. Asking learners to imagine being on an escalator meant that they were able to answer the question on forces better, and it seemed as if they understood the concept better. Another example was when one of the participants explained the equipment needed to conduct a specific experiment. The participant drew the different components on the board, repetitively named the pieces of equipment, wrote down the names, and showed the physical pieces of equipment to the learners.

Another strategy employed to good effect was the use of scientific terminology. All three participants used the correct scientific terms when they explained the subject content, modelling to learners how these terms should be used. Learners were also encouraged to use the correct terminology when responding to questions. However, the scientific term was not always explained effectively, with participants only offering the dictionary definition instead of using learner-friendly definitions. Questioning to facilitate reading comprehension was also used. In some cases, the participants asked higher-order questions, although most questions were simplistic and elicited yes/no answers. The choral response, often observed, could be interpreted as mechanical or as portraying nothing more than a basic understanding of the content and the question. The simplistic use of questioning becomes problematic when learners are faced with expository text that demands higher-order thinking. Moreover, the participants rarely asked follow-up questions and often provided the learners with the answers without allowing the learners to respond to a question to assess their understanding of a certain concept. It was clear that the participants trusted basic questioning as a measure to determine whether or not learners understood content they had dealt with previously or were dealing with in current lessons.

In addition to questioning, the participants also used inference, even though it was not explicitly taught. Instead of expecting learners to engage critically by making connections between the various aspects of the content, the participants (teachers) made the connections for the learners. An example was when a participant discussed examples of the different forces, such as gravity. This created an opportunity whereby the teacher could have asked the learners to provide examples of forces. Unfortunately, the teacher did not give the learners the opportunity to provide such examples to exhibit their understanding of the concept. Not all learners were able to make the connection between the presence of forces and how they affected an object. Text recognition was another strategy that was not optimally used. This technique refers to learners' ability to look at a text and understand how the different components are organised to facilitate meaning. An example of this is when learners have to know what the different symbols represent in an electrical circuit. The participants attempted to use text recognition when they explained the structure of the text. One participant explained the different components constituting a chemical reaction, e.g., reactants and products. These components are written on a specific side of equations. The participants mostly did not guide the learners in understanding the text for them to read it more effectively. There was an assumption about the learners' ability to interpret text, for example, graphs. The participants did not teach the text, for example, where the dependent and independent variables are placed on a graph. Consequently, some learners were unable to interpret the data given to them.

Furthermore, strategies like summarising and clarifying were hardly used. These strategies could aid the learners in their understanding of a specific text. Admittedly, science texts are not as lengthy as the narrative texts used in languages, but summarising could help learners break down the text further and explain it in their own words to aid the assimilation of knowledge. An example would be summarising the outcomes of an experiment to help with understanding. Another benefit of summarising is that it can act as a means of consolidating content that has already been covered. The researcher did not observe the clarification of concepts to a large extent in the classes. An example of clarification would be the effects of anodes and cathodes on the oxidisation of electrodes. Two participants (A and B) did not use clarification at all, but it was observed once in Participant C's lessons. The lack of clarification implies the participants assumed that the learners understood the content being taught. Consequently, some learners were confused as the concepts of distance and displacement were not explicated sufficiently for them to understand. Similarly, the learners were not taught to clarify for themselves. They were completely dependent on the teacher for clarification and, as a result, were unable to monitor their understanding as a form of metacognition.

Furthermore, the observation of lessons showed to what extent reading strategies were explicitly taught in the physical sciences classroom. Figure 2 below illustrates which strategies were explicitly taught by the participants.

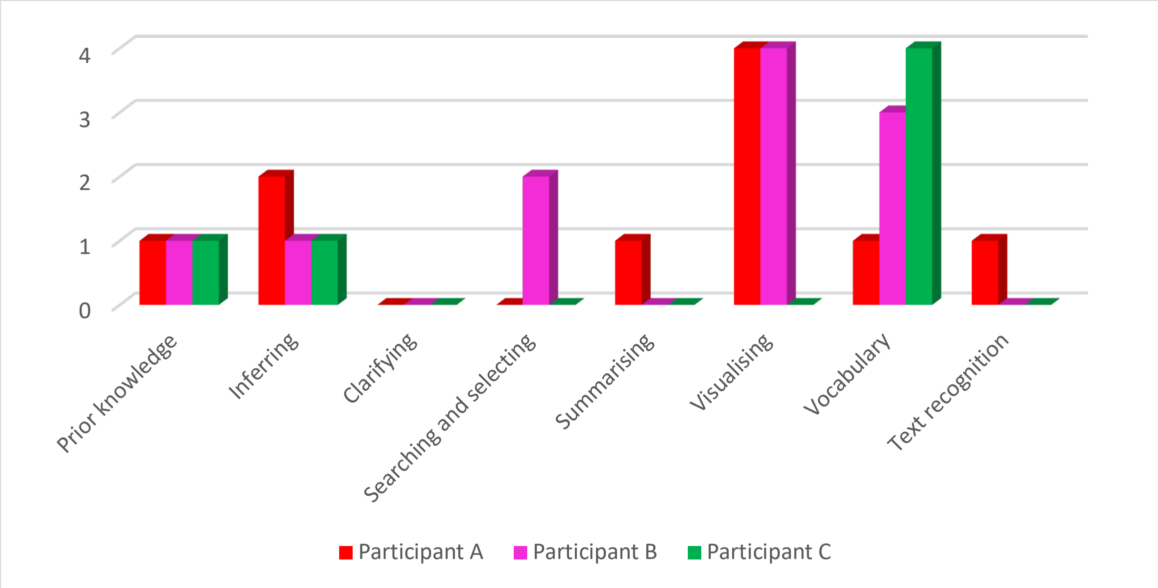

Fig. 2 Frequency of explicit teaching of reading strategies during the observed lessons

Explicit teaching of reading strategies was not evident in the lessons. The participants often modelled the use of reading strategies during their lessons, but they did not explicitly teach their learners how to use them. An example of this was the use of inference. In most instances, the participants made the inferences for the learners instead of teaching them how to infer. The participants attempted to help the learners with subject-specific vocabulary, meaning that the learners became dependent on the teacher to create the link for them so they could understand the content.

From the findings derived from the observations, it is clear that the participants used various reading strategies such as questioning, text recognition, activation of prior knowledge and teaching subject-specific vocabulary. It is unclear whether this was done consciously or whether it was just part of the normal language usage. Although the participants used different strategies, some were observed in all the lessons, like the activation of prior knowledge and focusing on subject-specific vocabulary.

Interviews

The study conducted semi-structured interviews to shed light on the participants' views on the importance of language in physical sciences classrooms and how it can help learners with comprehension. The participants felt that English language teaching has a role to play in physical sciences classrooms. Unfortunately, their answers showed they believed there was a difference between the English language used in English classrooms and the scientific language used in physical sciences classrooms. As a result, they do not think of language in the physical sciences classroom in terms of language structures like syntax, tenses, and vocabulary, as these structures are not part of the prescribed physical science curriculum. The participants indicated that learners are unable to think logically and read science texts with comprehension. Consequently, learners cannot apply problem-solving skills and reflect those skills when answering a variety of questions.

The participants offered different opinions on physical sciences teachers' responsibility to integrate content and language teaching. Two participants considered language teaching important in the physical sciences classroom, with one participant believing it has no role to play. Participant A believed that the role of the content teacher was to act as a bridge between the learners' home languages and the medium of instruction, which often differ. Furthermore, they argued that they must help learners use the correct language when communicating, and thus, should themselves have this skill. Participant A aptly explains that the teacher must "have the correct language ability, communication ability, the ability to talk and assess on a level that the kid understands". However, in this study, the participant's focus was BICS and not CALP, which is needed for higher-order thinking and comprehension. On the other hand, Participant A thought that combining written text and visual text like diagrams made it easier for the learners to internalise knowledge. Participant A stated, "the comprehension is better when you not only have words, but diagrams as well to reinforce concepts".

Similarly, Participant C believed that the content and language teaching should be integrated to assist learners. They felt their role was "to simplify language especially in my subject". Participant C concurred with Participant A that learners lacked the requisite reading skills to understand a science text fully. They both referred to the learners' lack of "mathematical intelligence". It was unclear what was meant by this expression. According to Participant B, learners need a basic understanding of English to start using basic words like "work" in the correct context. For example, "work" implies something like duty in an everyday context, whereas in a scientific context, it refers to the amount of energy used. Correspondingly, the participant believed that the learners' inability to read particular texts, for example, scenarios, showed a lack of basic language and reading skills. In this study, Participant C deemed reading strategies essential to identifying and learning content. They believed that asking a question "from a different angle" (Participant C) could assist a learner with the "repair" of knowledge, as it assisted learners in understanding that which was incorrectly understood and how (possibly) to repair such understanding.

Participant B felt that basic English proficiency was important as there exists "a lot of misconceptions" in physical sciences, and without basic language knowledge, learners would struggle to understand concepts. Similarly, Participant C thought language played an important role in simplifying concepts. Once again, linguistic skills were prominent, as Participant C stated that learners and teachers should use grammar correctly since the incorrect use of grammar could "confuse the learners". Although Participant C believed language was important in the physical sciences classroom and that the explicit teaching of language could be beneficial, they were unsure how to incorporate that into their lessons. As stated by the other participants, Participant C felt language should be used to explain terminology as well as the structures of questions, whereby learners are taught how to read and analyse questions and how this would assist them in answering such questions. Participant C's response about teaching scientific terminology was echoed by the other two participants, who also placed a high premium on understanding scientific terminology. Ultimately, the participants believed that their responsibility in terms of language teaching stretched as far as simplifying terminology and questions. This might not be sufficient for enhancing reading for meaning in a physical sciences classroom.

The interview findings indicated that the participants acknowledged how important language is in physical sciences classrooms. Although the participants were proficient in using English as the medium of instruction, their understanding of language teaching was limited to scientific language. This results in language teaching focused on terminology, not on developing higher-order thinking by fostering reading skills in the discipline. Ironically, all the participants indicated that reading was one of the main problems learners encounter when trying to understand scientific text. However, the participants displayed limited knowledge of reading strategies and mainly focused on explaining terminology.

Document analysis

Lesson planning

The study analysed the lesson plans supplied by the provincial DBE to establish the extent to which these plans help teachers integrate content and language teaching in physical sciences. Each lesson plan includes an introduction, main body, and conclusion. Teachers should spend a specific amount of time on each section, e.g., in a 45-minute lesson, five minutes are spent on the introduction phase, thirty minutes on the main content set out for the lesson, and the final ten minutes are spent on concluding the lesson. Figure 3 shows an example of how the introduction of a lesson plan about displacement was organised.

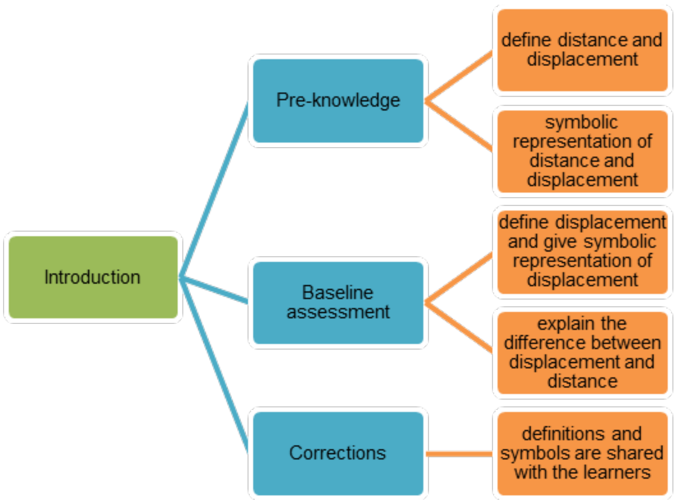

Fig. 3 Lesson plan development (Swart, 2021: 88)

As seen in Figure 3, the introduction is divided into three different sections. Each section focuses on different components of knowledge to ensure the activation of prior knowledge. The lesson plan also shows that only five minutes are allocated for the introduction. This could be problematic as teaching might become mechanical in as much as it prompts learners to recite content such as definitions instead of showing a real understanding of the previous work. The small amount of time does not allow the teacher to check that all the learners understand the previous content and enhance retention. Similarly, the thirty minutes allocated to teaching new subject content demonstrates an assumption that learners would gain sufficient understanding. The lesson plan does not mention the use of reading strategies and only focuses on terminology.

The lesson plan shows that teachers are compelled to include how much time they spend on content in one lesson, which does not allow for the integration of content and language teaching and, specifically, teaching reading strategies to assist with comprehension. Consequently, teachers predominantly focus on the content to be covered within set time frames, not on the linguistic knowledge and skills learners need to make sense of subject content.

The study also analysed the CAPS document for physical sciences. The CAPS document states that specific skills like "hypothesising, identifying and controlling variables, inferring, observing and comparing, interpreting, predicting, problem solving and reflective skills" are needed to understand physical sciences content (DBE, 2011: 8). The physical sciences CAPS document refers to language teaching in the content classroom, but does not give clear guidance on how language teaching should happen (DBE, 2018:14). Prefixes and suffixes are examples of language concepts. According to the CAPS document, learners must be able to identify the different prefixes and suffixes relevant to physical sciences, but once again, no pedagogical guidelines are provided. Apart from understanding and using prefixes and suffixes correctly, learners should compare and contrast different concepts to derive meaning, as stated in the CAPS document. An example is that learners should be able to draw the link between bond energy and length energy. A deep understanding of these two separate concepts is required before the higher-order activity of comparison and contrast of the concepts can be expected.

Other shortcomings of the CAPS document regarding language teaching are time allocation and content-heavy lessons. The CAPS document indicates which content should be covered per unit and how much time should be spent on these units. Nowhere in the document does it allow for the active teaching of language/reading during lessons. Therefore, the document does not allow time for teachers to develop the learners' scientific literacy. The document focuses on knowledge/content, which is presented as lists of concepts that should be checked off.

The Manual for Teaching English Across the Curriculum was released by the DBE in an attempt to bridge language gaps, with the document's main aim being to guide content teachers on how to integrate content and language teaching (DBE, 2013). As in the CAPS document, the manual also states the importance of language awareness and the ability to scaffold the use of language in content teaching (DBE, 2013: 6), yet falls short of providing meaningful pedagogical guidelines.

The use of reading strategies to preview text is provided as an example of a language strategy. The document states that learners must be able to use these strategies when previewing text, e.g., "monitoring their understanding, determining the most important ideas and relationships between them, remembering what they read, and making connections and inferences" (DBE, 2013: 11). Even though the manual mentions these strategies, the assumption seems to be that content teachers know how to teach them. This is problematic since content teachers do not receive the same level of language training as specialist language teachers. By stating this, we do not suggest that they should, but it cannot be presumed that language knowledge is necessarily in place. Consequently, content teachers might feel ill-prepared to teach language aspects.

The document analysis revealed that the physical sciences CAPS (DBE, 2018:14) document states that content teachers are expected to teach language aspects like reading and language in their classes. Unfortunately, no assistance is given to teachers in any of the documents analysed for this study. Consequently, content teachers do not teach reading/language, perhaps because they lack sufficient pedagogical knowledge.

DISCUSSION

The findings emphasise how crucial reading comprehension is to the assimilation of knowledge. However, the study found that these strategies are not explicitly taught in the physical sciences. The participants used some of the reading strategies suggested by McEwan (2007: 8), as seen in Table 1, more often than others, with some hardly ever used. This is also seen in Figure 1, which shows the participants' frequency of using reading strategies during the lesson. The observations showed that participants frequently activated prior knowledge, but that was limited to the participant providing the activation and assumed that the learners understood previously covered content. Furthermore, the participants did not actively teach reading strategies, meaning the learners were not taught how to use reading strategies themselves to assist with comprehension. The comprehension of physical sciences content relies heavily on understanding subject-specific vocabulary and concepts. Consequently, learners need a high level of scientific literacy to understand subject-specific content. If science teachers do not assist learners in becoming scientifically literate, it could affect the comprehension of concepts negatively since it might lead to a mechanical recital of concepts like definitions instead of a deep understanding. Modelling and explicit teaching of reading strategies might eventually result in learners being able to use reading strategies automatically (Swart, 2021: 50). Furthermore, teaching reading strategies should not be limited only to the physical science classroom but also to other subjects taught using English as the medium of instruction to assist with the full comprehension of the content of that specific subject.

In terms of the participants' views on language teaching in the physical sciences classroom, they acknowledged the need for language awareness for learners to understand the content. The focus is mostly on basic communication and not academic language, which jeopardises learners' ability to engage in higher-order thinking, resulting in them being unable to respond to questions in a way that shows ample understanding of the text. As much as the participants felt that the use of reading strategies was important, they were not sure how to use or teach most of the reading strategies that would aid comprehension.

Physical sciences teachers are neither trained to be language teachers nor are they provided with sufficient guidance on the integration of content and language teaching (Swart, 2021: 87). Although the physical sciences CAPS document states that language, specifically reading, must be taught in the science classroom (DBE, 2018: 14), it does not help teachers with the pedagogy of teaching language in the content classroom. Furthermore, as seen in the lesson plans, language teaching is not considered, and the lessons are packed with content with no reference to language/reading. In an attempt to assist teachers, the DBE compiled a Manual for Teaching English in the Content Classroom to assist content teachers with teaching reading. Unfortunately, as with the CAPS document, the manual lacks real substance on how language should be taught.

Teachers' role in teaching reading strategies in their disciplines cannot be overstated. Physical Sciences teachers can help their learners by using these strategies to improve critical engagement and deep understanding. Furthermore, teachers should not just model these strategies but also teach them explicitly so that learners can engage actively with texts for meaning-making. With this in mind, physical sciences teachers need assistance with content-specific language and reading pedagogy.

CONCLUSION

This study emphasises the importance of reading strategies in content classrooms. The data show that reading strategies are not always taught to assist with comprehension. Scaffolding reading and language in physical sciences classrooms might improve South African learners' performance in the subject. To this end, the DBE might consider making effective changes to subject-specific curriculum documents to include language teaching. Furthermore, the Manual for Teaching English in the Content Classroom issued by the DBE should be replaced with a document that assists teachers in a more focused and systematic manner in teaching language and reading skills. Using reading strategies to improve comprehension is not limited to South Africa, and new developments can be applied throughout the world, especially in places where learners learn through the medium of a second language. However, adjusting the curriculum to include language teaching in content subjects is not sufficient. Content teachers must be trained in the use of language teaching in their specific subjects.

Future studies could help create a clear model to assist content teachers with teaching reading strategies to improve comprehension. Research focusing on the development of clear guidelines and textbooks on how content teachers are trained could equip them with the necessary skills not only to use reading strategies but also to teach these to learners.

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BIOGRAPHICAL NOTES

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ADDENDUM A

Observation Schedule

Title of study:*PHYSICAL SCIENCE TEACHERS' USE OF READING STRATEGIES IN A SOUTH AFRICAN CONTEXT*

Researcher:

Date:

Lesson topic:

Duration:

Teacher: A/B/C

Observation Checklist

No.	Reading strategy	Used by teacher	Taught to learners	Questions linking to strategy
1	Prior knowledge activation			
2	Inferring			
3	Clarification			
4	Questioning			
5	Searching & Selecting			
6	Summarising			
7	Visualising			
8	Teaching subject specific vocabulary			
9	Text recognition			

Comments on classroom setup (posters, visual aids, use of aids)

Vocabulary (Word explanation vs defining, word attacking, repairing of vocabulary? used by learners): e.g. looking at the origin of words; root words; role of prefixes and suffixes.

Text recognition (explanation of text structure, explanation of language specific to text e.g. tense).

Language (awareness of syntax and lexical inferences).

Language (awareness of semantic inference).

Questioning to assist with understanding (does it allow for critical engagement and thinking i.e. open-ended questions (on which cognitive levels according to Bloom's taxonomy); does the teacher mostly use yes/no questions

Educator proficiency (language use, spelling, pronunciation)

Other comments and observations regarding reading and comprehension.

ADDENDUM B

Interview Schedule

1. In your own words, how would you define the role of language in terms of a) instruction, b) understanding the concept taught and c) relation of facts in your lesson?

2. Do you consciously incorporate elements of language in your lesson planning?

3. Would you provide examples of how you integrate language into your lesson plan and other class-based activities?

4. Would you say that these interventions have been successful?

5. In your opinion, what are some of the main reasons why learners fail to understand your subject's content?

6. Do you pay specific attention to reading and reading strategies when you teach?

7. How to you incorporate reading into your lesson?

8. Which "repair" strategies do you use should a learner struggle with comprehension?

9. How confident are you to teach language in your content subject?

10. What training or assistance have you received in you teaching career that would assist you with teaching language in your content subject?

11. Do feel that the training was sufficient to assist you in the support of learners who struggle with language comprehension?

12. Would there be a benefit in getting training in language?

13. If there is a benefit what would it be?

14. Do you feel that language has a place in your subject? If so, why?

15. How would you describe your role with regards to language teaching?