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The readability of a high stakes Physics examination paper

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This article reports on the readability of a Physics examination paper written by grade-12 students. A sample of 500 scripts was analysed for readability problems associated with linguistic features synonymous with scientific writing. The study revealed that where a question displayed a linguistic feature of scientific writing, this contributed to students doing an incorrect calculation, focusing on the wrong aspect of the question, repeating a segment of a question, and misinterpreting a word or a phrase. In view of these findings, the article argues that greater attention needs to be paid to the language of science in the classroom.

Die leesbaarheid van ’n deurslaggewende Fisika-eksamenvraestel

Hierdie artikel doen verslag oor ’n deurslaggewende Fisika-eksamenvraestel wat deur graad 12-leerders geskryf is. ’n Steekproef van 500 leerders se antwoordskrifte is vir leesbaarheidsprobleme wat met die geïdentifiseerde linguistiese eienskappe gepaardgaan, ontleed. Die studie het getoon dat waar ’n vraag ’n linguistiese eienskap van wetenskaplike skryfwerk vertoon het, dit daartoe bygedra het dat leerders ’n verkeerde berekening doen deur op die verkeerde aspek van die vraag te fokus, ’n segment van ’n vraag herhaal en ’n woord of frase verkeerd interpreteer. In die lig van hierdie bevindings betoog die artikel dat meer aandag aan wetenskapstaal in die klaskamer geskenk moet word.

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Students who read words accurately and fluently find it difficult to comprehend text in particular disciplines. One of the sources of this problem is the "academic language" that is used in science, mathematics, and social studies texts compared to the language encountered in English language arts (mostly narratives, Snow 2010). According to Snow (2010: 450), among the most commonly noted features of academic language are

> ... conciseness, achieved by avoiding redundancy; using a high density of information-bearing words, ensuring precision of expression; and relying on grammatical processes to compress complex ideas into few words.

Many scholars have suggested, in particular, how the language of science with its own specific genre often serves as a barrier to the learning of science.[1] Students often experience alienation from science due to the distinctive grammatical features and language structures of academic language in the discipline.

In order to understand how this alienation arises, we need to consider how academic language is used as a tool for participating in a community of practice (Carlsen 2008: 58). This view is advanced by social constructivists who claim that meaning is constituted through a variety of social practices, in particular language, which is a primary mediator. Vygotsky (1978: 50-65) viewed learning as a type of enculturation in which learning occurs through adopting the cultural practices, in particular language, of a social group situated in its distinct culture. He argues for the central role of language in learning by maintaining that it mediates the communication which enables thinking with others (Wells 2007: 244-50). He discusses language as a semiotic system that uses signs, symbols, and technical tools to constitute the meanings of a culture. Language therefore mediates thinking by imparting meaning to action. He claims that this interrelatedness of thought, action, and semiotic (meaning-making) tools is fundamental to learning and development. According to Hasan (2002: 1),

> ... in the Vygotskian oeuvre, the phrase *semiotic mediation* has come to stand for *mediation by means of the linguistic sign*.

1 *Cf* Brown 2004, Gee 2004, Lemke 1990, Varelas *et al* 2002, Wellington & Osborne 2001.

Systemic functional linguistics (Halliday 1978, 1993 & 1994, Hasan & Martin 1989: 100-10) also conceptualise language as a semiotic tool. Halliday (1993: 93) describes language as a semiotic tool in learning as follows:

> When children learn language, they are not simply engaging in one type of learning among many; rather, they are learning the foundations of learning itself. The distinctive characteristic of human learning is that it is a process of making meaning – a semiotic process; and the prototypical form of human semiotic is language. Hence the ontogenesis of language is at the same time the ontogenesis of learning.

This claim is supported by Lemke (1990: 24-35) who described learning in science as a process of understanding the linguistic structure of content and acquiring the functional uses of scientific language in the classroom. Halliday (1993: 84) demonstrated that scientific language contains unique lexicon, syntax, semantics, and structure which enable it to fulfil a functional role in meeting "the needs of scientific method, and of scientific argument and theory". From the perspective of functional linguistics, learning the specialised language of science is synonymous with learning science, and the functional features of science academic language has been the focus of a great deal of research in science education.In particular, the readability of science text has gained much attention from scholars in science education. Numerous studies have been conducted where the readability of scientific text has been measured using either the Flesch formula, or the Fry formula (or SMOG formula).[2] These formulae typically take into account variables such as the words per sentence, number of unfamiliar words, syllables per word, the average number of sentences per paragraph, and the percentage of sentences written in the passive voice to generate a numerical value for readability.

However, the issue of quantitatively measuring the readability of text by reducing it to a numerical value has been questioned.[3] This scepticism relates mainly to the uncertainty in classifying words as unfamiliar to the reader, and the fact that the formulae are calculated on factors at the sentence and subsentence level, thereby ignoring the complexity of information structures. Nevertheless, studies where

2 *Cf* Chiang-Soong & Yager 1993, Daniels 1996, Homan *et al* 1999, Flesch 1948: 25, Fry 1968: 48, McLaughlin 1968: 12.

3 *Cf* Allan *et al* 2005: 1, Chambers 1983: 3-13, Dempster & Reddy 2007: 906-25.

formulae have been employed concentrated on the analysis of science textbooks. The findings refer to the complexity of science text as being over-demanding on the linguistic proficiency of students (Merzyn 1987: 483-9).

However, there is a gap in research on the readability of science examination questions (Clerk & Rutherford 2000: 703-9). Studies conducted in South Africa have shown readability of questions as a significant factor in the performance of students. In a study on the readability of multiple-choice questions that were administered to grade-12 students, Clerk & Rutherford (2000: 715) found that "language problems do sometimes masquerade as misconceptions". In addition, a study by Dempster & Reddy (2007: 906-25) investigated the relationship between readability of text-only multiple-choice questions from the Trends in International Mathematics and Science Study (TIMSS) of 2003 and the performance of South African students. Their study showed that sentence complexity influences the performance of students on TIMSS items.

My study explores the issue of readability of academic language text such as written scientific language by investigating the readability of questions in a high stakes national Physics examination paper. The school subject Physical Sciences includes Physics and Chemistry, and these two fields of study are examined separately in Grade 12. The students who formed the focus of this study were the first group to write a national examination on a new curriculum which was underpinned by outcomes-based education. The teaching and learning approaches implicit in the new curriculum are to a large extent founded upon the basic tenets of social constructivism alluded to earlier. In adopting a social constructivist approach in classrooms, it was expected that students would have the opportunity to express and exchange ideas with peers and the teacher on a specific topic, and thereby become participants in a community of practice where scientific language would serve as a primary mediator. It was therefore anticipated that with this curriculum reform, students would have acquired greater facility with the scientific language, and would be better placed to read scientific text than their predecessors (RSA 2003). There was also an expectation that this cohort of students would perform better as a result of these reforms. However, a bleak picture emerged with the analysis of the results. Of the 218.156 students who wrote the paper, 98.060 students (45% of the total) achieved below the pass level of 30%, and only 62.530 (28.7%) achieved 40% and above (RSA 2008: 5). The national results for Physical Sciences did not differ significantly from those of previous years. International studies on student responses to test and examination items have revealed student misconceptions in science and these have contributed significantly to poor performance in this subject.[4] This study assumes another focus. In view of the reported readability difficulty students experience with scientific text, I investigated the prevalence of this problem in the readability of questions in the Physics examination, by analysing the questions in the Physics examination, and the student responses to these questions.

The following questions formed the focus of my study:

- What linguistic features of academic language text are prevalent in the Physics examination paper?
- To what extent did the linguistic features of academic language used in a Physics paper contribute to readability problems experienced by students?

In analysing questions in a Physics examination paper I assumed a functional linguistic perspective on academic language.

1. Framework on linguistic features of scientific writing

In assuming a functional linguistic perspective on scientific writing, key linguistic features can be identified and I was to a large extent guided by these features. I will now discuss some features which have been identified by scholars, and the challenges they pose to readability.

1.1 Lexical density

According to Fang (2004), one of the distinguishing features of scientific writing is that it has a high density of information. Density is described by the number of content-carrying words which are packed into the clause of the sentence (Halliday 1993: 69-85). Content-carrying

4 *Cf* King 2010: 565-601, Moore & Harrison 2004: 1-3, Thompson & Logue 2006: 553-9.

words include nouns, verbs, adjectives, and some adverbs while non-content-carrying words include prepositions, conjunctions, auxiliary verbs, some adverbs, determiners, and pronouns (Eggins 1994: 5-10). In everyday written language there are 4-6 content words, but in scientific writing this is considerably higher, often as much as 10-13 words per clause (Halliday 1993: 69-85).

1.2 Subordinate clauses

Subordinate clauses are those whose existence is dependent on the main clause. Unlike embedded clauses, they are not part of another clause and are typically introduced by conjunctions (for example, *while*, *because*, *if*, *as*). Subordinate clauses in science writing become a source of reading difficulty when their subjects and auxiliary verbs are removed for the sake of linguistic economy (Fang 2006: 491-520).

1.3 Complex sentences

A feature of scientific writing is complex sentences with multiple subordinate clauses that are linked in a logical dependency relationship. This differentiates it from everyday language where the clauses that are chained through coordinating conjunctions (for example, *and*, *and then*) each contribute independently to the spoken discourse (Fang 2006: 491-520).

1.4 Unfamiliar words

Unfamiliar words in scientific writing are words that rarely occur in the reader's everyday spoken language. Halliday & Martin (1993: 5-9) state that scientific writing is replete with such words (for example, *photo-electric* or *electrolysis*) that are used to convey the specialised knowledge of science. Significant comprehension challenges can arise when there is a heavy concentration of these words within a sentence.

1.5 Ambiguous words

Scientific language employs words from everyday language that have a different meaning in a scientific context (Lee *et al* 2008: 31-52). Due to their dual meanings words such as *force*, *energy*, *matter,* and so on appear to be ambiguous to students who lack proficiency in the language of science.

1.6 Passive voice

A tendency in scientific writing is to use the passive instead of the active voice (Krajcik & Sutherland 2010: 456-9). According to Fang (2006: 504), a function of this passive voice is that it enables the

> ... author to achieve some degree of objectivity and authority by not mentioning the human/animal actors involved in the scientific process.

Although the above features may appear in other discipline-based texts, they seem particularly concentrated in science texts.

2. Methodology

In order to facilitate the capture and analysis of data from the Physics examination paper and the student scripts, a readability matrix was developed. I analysed all the questions in the Physics paper, with the intent of identifying the linguistic features of scientific language that were prevalent in each of the questions. The three-hour Physics examination paper totalled 150 marks and comprised 15 questions. The identified linguistic features and questions, which reflected these features, were then represented on a matrix. Not all questions reflected linguistic features associated with scientific writing. This process of identifying linguistic features of the scientific genre in the questions was validated by two experts in functional linguistics. The one expert was based at a local university, while the other was an international scholar. I then analysed a random sample of 100 scripts drawn from the batch of 500 scripts provided by the Gauteng Department of Education. The batch of 500 scripts was a random sample that was provided. In this analysis of student responses, my focus was to seek any evidence which would suggest that an incorrect response to a question was attributed to a readability problem related to a linguistic feature inherent to that question. Based on the evidence, I was able to categorise the responses into readability errors. The identified linguistic features and the related categories of readability errors constituted the framework for the readability matrix (*cf* Table 1). The cases of readability problems that were recorded and reported on the matrix represented a link between the linguistic feature and the category of readability error attributed to the feature. On the matrix the cases are shown at the intersection of the row (linguistic feature) and column (category of error). The developed readability matrix was then used in the analysis of the remaining 400 scripts. The results reported in this instance are therefore based on the analysis of 500 scripts.

I decided to probe the causes of the readability problem in a second phase to the study. Due to this being an exit examination, I was unable to interview the students whose scripts were analysed. Another smaller sample of students was therefore sought so that I could probe students on the readability problems evident from the script analysis. I compiled a test of the same questions that featured in the script analysis, and then administered it to a group of 30 Grade 12 students at a school that was conveniently located in my neighbourhood. This was a later cohort of students to the one which had written the 2008 high stakes national examination. I followed the same procedure as I had used previously in analysing the responses to the selected questions. Based on this analysis, I identified 21 students who had displayed similar errors to those that were most prevalent from the script analysis. The students were interviewed individually. The course of the interview was directed primarily by the students' responses to the test questions. I probed students on their responses by asking them to explain the reasoning behind their answers.

3. Findings

In Table 1 the developed readability matrix shows the linguistic features that were identified from the analysis of questions, and the errors attributed to readability were related to each feature. The results of the examination script analysis are shown by indicating the number of cases of a readability error associated with a linguistic feature of a particular question.

Table 1: Readability matrix

Categories of errors attributed to readability				
Linguistic features	Incorrect calculation	Focuses on wrong aspect of question	Repeats a segment of a question or rephrases the question	Misinterprets a word
Lexical density		Q 5.3 (55 cases)	Q 5.3 (34 cases)	
Subordinate clauses		Q 15.3 (121 cases)		
Unfamiliar words		Q 5.2 (46 cases)		Q 5.2 (53 cases) Q 10.1 (80 cases) Q 11.1 (56 cases)
Complex sentences	Q 8 (48 cases)			

I will now discuss exemplars of cases identified from the examination script analysis by explaining the linguistic feature of a question and the readability errors which emanated from it. The linguistic features which were evident in the questions included density of information, subordinate clauses, unfamiliar words and complex sentences. I also use the interview data in explaining these errors.

3.1 Lexical density

The second sentence (extract 1) of question 5.3 was densely packed with information that students found difficult to assimilate.

Extract 1:

5.3 A traffic officer appears at the scene of the accident and mentions the dangers of a head-on collision. He mentions that for cars involved in a head-on collision, the risk of injury for passengers in a heavier car would be less than for passengers in lighter car. Use principles of Physics to explain why the statement made by the traffic officer is correct.

This sentence has a total of 11 non-repeated content words in two clauses (in bold) out of a total of 25 non-repeated words, yielding a lexical density of 44%. A total of 89 cases of readability problems attributable to lexical density were identified, with 55 cases resulting in students focusing on the wrong aspect of the question. In 34 cases students merely repeated a segment of the question or rephrased it in their answer.In answering this question students were expected to use Physics principles to explain how the masses of the cars affect the risk of injury.

The following examples of cases from the examination scripts show how students neglected the masses of the cars and instead focused on another aspect in the question. In the first example, the student refers to the speed of the cars, which despite being a factor in risk of injury, was not the focus of this question. In the second example, the student refers to modern cars which crumple upon impact. Although this is correct, it again represents a case where the student has missed the focus of the question.

> It is too dangerous for people who are inside the car, because they will all have an accident that is caused by one person that has more speed in the road.

> Modern cars designed crumple partially on impact, and this increases the dangers of risk in the injury.

Twelve of the interviewed students displayed a similar error by focusing on the speed of the car instead of the masses. Nine of these students explained that they had overlooked the masses of the cars when reading the question. A student explained this as follows:

> I was not sure that the question was asking about masses. I just read about the head-on collision and knew this had something to do with the speed of the cars. It was a lot for me to read and I completely missed the part about the masses.

The following cases from the examination scripts provide evidence of students either repeating a segment of the question or rephrasing it, without any attempt at explaining the statement using a Physics principle:

> In terms of mass, both cars are different in mass, therefore passengers in the light car will be more at risk.

> Correct because of the mass of the objects.

> A heavier car has much more mass than the smaller car. This results in the smaller car being permanently damaged.

Nine of the interviewed students displayed this error. Six of these students explained that repeating aspects of the question was a strategy they employed in trying to understand what was required. The following response illustrated this:

> I was very confused with the question. I just picked on things that were important and tried to make sense of it.

3.2 Subordinate clauses

The first sentence of question 15.3 (Extract 2) has a subordinate clause where the subject is missing.

> Extract 2:
>
> 15.3 The intensity of the incident radiation on the metal plate is increased whilst maintaining a constant wavelength of 200 nm. State and explain what effect this change has on the following:
>
> 15.3.1 Energy of the emitted photo-electrons.
>
> 15.3.2 Number of emitted photo-electrons.

The grammatical structure resulted in difficulty in identifying the subject. In this extract, the subordinate clause "whilst maintaining a constant wavelength of 200 nm" is implied to mean "whilst [the incident radiation is] maintaining a constant wavelength of 200 nm". In addition, in the second sentence (extract 2) the subject is also missing. The subject in this instance could have been more clearly identified if the sentence was reconstructed as follows: "State and explain what effect this [increase] has on the following".

There were 121 cases of errors attributable to this linguistic feature. In all cases the students focused on the wrong aspect of the question. For example, in question 15.3.1, where the students were asked to state and explain the effect of the change on the "Energy of the emitted photo-electrons", students correctly stated that the energy of the electrons remains the same, but in the explanations they erroneously answered as follows:

> Metal plate maintains a constant wavelength;
>
> Intensity remains same in wavelength, and
>
> Same 200 nm for intensity.

The correct explanation for this is that the incident radiation or photo-electrons maintain a constant wavelength. The students in this instance correctly alluded to the wavelength but their failure to identify the subject in the sentence probably contributed to their incorrect answer. The interviews helped clarify these responses. Seven of the ten students who answered similarly in the test were asked to explain what the question demanded of them. All seven students indicated that they were unclear about the "change" that was being referred to in the question.

3.3 Unfamiliar word

In the second sentence of question 5.2 (Extract 3) the word "assumption" appeared to be unfamiliar and incomprehensible to the students. This word is seldom used by students in their conversational language, but is commonly used in the discipline in order to specify conditions for the application of certain physical laws. There were 99 cases of errors attributable to the unfamiliarity of this word. In 46 of these cases students focused on the wrong aspect of the question, while in 53 cases they misinterpreted the word.

Extract 3:

The most common reasons for rear-end collisions are too short a following distance, speeding and failing brakes. The sketch below represents one such collision. Car A of mass 1000 kg, stationary at a traffic light, is hit from behind by Car B of mass 1200kg, travelling at 18 $m.s^{-1}$. Immediately after the collision Car A moves forward at 12 $m.s^{-1}$.

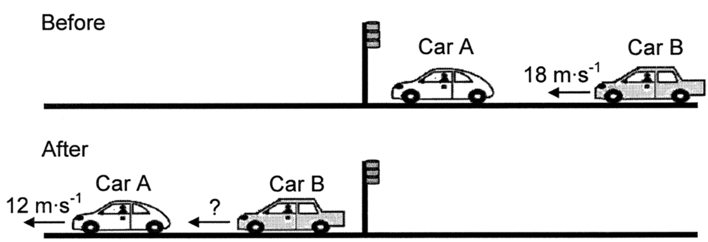

Figure 1: Diagram for Question 5

> 5.1 Assume that linear momentum is conserved during this collision. Calculate the speed of Car B immediately after the collision.
>
> 5.2 Modern cars are designed to crumple partially upon impact. Explain why the assumption made in QUESTION 5.1 may NOT be valid in this case. The following cases illustrate how students focused on "crumple partially on impact" instead of addressing the *assumption* made on the conservation of linear momentum during the collision:

> The crumple zone in the collision increases the time which decreases the impact/force according to F_{net}=p/t. Because modern cars are designed for the safety of their passengers, they are designed to crumple partially.

> They are made to crumple to increase the time and decrease the impact so the material has to be softer.

A common misinterpretation was that students took the word "assumption" to read "calculation" and hence referred to the calculation done in 5.1. The following responses indicated this:

> Because the car was not moving fast.
>
> Car B's velocity decreases but after the collision it accelerated, which means that velocity should increase.
>
> Because immediately after the collision car A moves forward at 12m.s-1, so the impact immediately took place after the collision.

Ten of the thirteen students who had made a similar error in the test when interviewed showed a lack of understanding of the word "assumption". They had all taken this word to mean calculation. The following interview response attests to this:

> I thought they wanted us to use the calculation I made in 5.1 to answer about it. I thought assumptions means to calculate. It is like when you assume from a calculation.

Other examples of unfamiliar words which appeared in the paper are "define" (question 10.1) and "variables" (question 11.1) which appear in extracts 4 and 5, respectively:

> Extract 4: Define the electric field at a point in space.
>
> Extract 5: Name TWO variables that the students would have controlled in each of the experiments where learners investigate the conducting ability of two wires, P and Q, made of different materials.

There were 80 cases where students misinterpreted the "define" and instead described the properties of the electric field. The expected answer for this question was "A space where an electric charge will experience an electric force". The following cases illustrate this readability problem:

> Electric field in space is not equal
>
> The electric field is increasing at point P
>
> Electric field becomes stronger as it gets to the centre
>
> The electric field are lines that pass between two charges

"Variable" is a word that is seldom used in the everyday language of students, and 56 cases showed students misinterpreting the word to mean some action that needs to be taken to ensure the validity of the results. In science, the term "variable" in fact refers to a factor or condition that is subject to change, especially one that is allowed to change in a scientific experiment to test a hypothesis. In this question, students were required to identify the variables to be controlled in the experiment, namely the temperature, cross-sectional area and length of conductor. The following student responses show a very clear reference to temperature as the variable to be controlled, but due to a lack of understanding of the word "variable" students were not explicit about it:

> The student was meant to cool the circuit after readings; The student needs to disconnect wire from heating because it cause change in resistance.

Similarly, as was the case with the word "assumption", the students when interviewed did not have a scientific understanding of the words "define" and "variable".

3.4 Complex sentences

Question 8 of the examination paper contained a complex sentence (second sentence of Extract 7). This sentence has an embedded clause, as well as a subordinate clause. The relative pronoun "which" introduces the embedded clause to modify the same noun “detector”. The conjunction “as” then introduces a subordinate clause.

> Extract 7: An ambulance travelling down a road at constant speed emits sound waves from its siren. A lady stands on the side of the road with a detector which registers sound waves at a frequency of 445 Hz as the ambulance approaches her. After passing her, and moving away at the same constant speed, sound waves of frequency 380 Hz are registered.

There were 48 cases of interpretation errors which were attributed to this linguistic feature. In the paper, students were asked to calculate “The speed at which the ambulance is moving”. The solution method was to establish two equations, one for the ambulance approaching the lady and the other for the ambulance moving away from her, and then to solve the equations simultaneously. In the majority of cases the students used the correct formula in generating an equation for the ambulance approaching, but incorrectly took the frequency of the source (the ambulance siren) as 445Hz. This was, in fact, the observed frequency that was measured with the detector.

In the above case, it would appear that the student failed to realise that the pronoun “which” referred to the detector, but instead assumed that this was the actual frequency of the ambulance siren. This readability problem could have been averted if the complex sentence were replaced with the following two sentences:

> A lady stands on the side of the road with a detector. The detector registers sound waves at a frequency of 445 Hz as the ambulance approaches her.

Nine of the eleven students who displayed a similar response in the test explained that they had misread the question. This is shown in the following interview response:

> I knew what to do because we did lots of examples in class like this but got confused over the actual frequency of the siren. I thought it was meant to be 445.

4. Discussion

A significant number of cases (493) were identified where students misread a question. Linguistic features of the Physics examination paper such as the complexity of sentences, subordinate clauses, lexical density and unfamiliar words appeared to influence the readability of questions. This finding echoes research conducted by Dempster & Reddy (2007:906-925) on student responses to multiple-choice items in the TIMSS study. They also identified sentence complexity and the unfamiliarity of certain words as possible factors which affected readability of items, resulting in students resorting to random guessing on items or choosing incorrectly. I do not suggest in this instance that the difficulties detected in the student responses to the examination questions are solely attributed to their ability to read the question. Other factors such as a lack of conceptual understanding could have played a role. In this regard, Dempster & Reddy (2007: 920) point out that readability measures do not prove to be reliable predictors of students choosing the correct answer, and the problems of readability of items "overlie a lack of knowledge, skills, and reasoning ability in science". I therefore sought validity for the claims made about the readability of the questions by further probing students who had displayed the types of errors identified from the analysis of the examination scripts. It was evident from the interviews that the readability of the questions was a very significant factor in the manner in which students had responded to the questions, and the problem of readability appeared to be more serious than the statistic of the cases identified through the examination script analysis.

There was much evidence in the student responses to suggest that students who did have competence in the scientific knowledge being referred to in the question had failed to answer correctly due to the readability of the question. In addressing this issue, Thompson *et al* (2002) make certain recommendations on how item readability can be improved. These include replacing complex and compound sentences with simple ones; using everyday words rather than complex technical vocabulary, and avoiding ambiguous words.

I believe the problem of readability of scientific writing needs to be tackled at a more fundamental level. According to Lemke (2001: 5), students need to become empowered in "... the organization and logic of scientific ways of using language" and schools must assume this responsibility. Students need to be able to read and write in the language of science in order to effectively communicate in science. For this to happen, teachers need to have a "... better understanding of the central role language plays in shaping experience/reality and hence in learning" (Fang 2004: 345). Science teachers are not generally well-prepared to help their students penetrate the linguistic puzzles that science texts present. Snow (2010: 452) claims that teachers

> ... recognize that teaching vocabulary is key, but typically focus on the science vocabulary (the bolded words in the text), often without recognizing that those bolded words are defined with general-purpose academic words that students also do not know.

Teachers need support in this regard and science textbooks which traditionally serve as a source of scientific knowledge, curriculum planning and teaching ideas (Malcolm & Alant 2004: 50-5) should be revisited in providing activities which target the development of the specialised language of science (Draper 2002: 357-84). Teachers can provide a range of support, for example, "... by probing students for more information, restating students' spoken ideas to clarify their reasoning, asking students to state ideas aloud in choral speaking, or getting students talking in small groups" (Gagnon & Abell 2009: 51), so that students communicate with higher levels of scientific language. In light of these recommendations, I suggest further studies to investigate the practice of science teachers in explicitly developing the scientific language of students.

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