FOREIGN LANGUAGES IN AFRICAN SCIENCE CLASSROOMS: PERSPECTIVES ON AND APPROACHES TO LANGUAGE USE DURING TEACHING

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ABSTRACT

Africa is perhaps the only continent in the world where most formal or school education is conducted in instructional languages that are foreign to most learners and their teachers. In contexts where formal learning is conducted in a foreign language, achievement of general proficiency in the instructional language is a necessary first step if any learning is to be expected in that language. In this article, the objective is to argue an appropriate perspective on – and suggest approaches to – the use of (the foreign) language by science teachers during teaching. This article is the outcome of sustained literature reviews of cross-national research on language in science education over the last 40 years. In this article, a plural nature of school science is adopted, including it being a distinct language foreign to all learners, irrespective of their first language. Therefore, the main objective of this article is to highlight the role of the instructional language as used by the science teacher and in science texts. This article targets the science teacher with regard to the well-known need for teacher intervention in the learning of school science.

Keywords: Africa; foreign language; language of instruction; components and nature of words in the language of instruction; science learning and teaching; learning context; science education research.

INTRODUCTION AND OVERVIEW

> "What kind of science can a child learn in the absence, for example, of basic language competence and an attendant inability to handle concepts?" (Achebe, p. 162)

Despite the United Nations Educational, Scientific and Cultural Organisation's (UNESCO) assertion that educating learners in a language they understand best is a tenet of good practice (UNESCO, 2007), Africa remains the only continent in the world where formal education is generally conducted in instructional languages that are foreign to most learners and their teachers. The continent has in this regard been balkanised into Anglophone, Francophone and Luzophone states, with reference to the European (former colonial) languages; English, French and Portuguese respectively. In the special case of Tanzania, the balkanisation may be referred to as a "Swahiliphone". In Tanzania, Swahili, the mandatory language of primary school education – but also used widely in secondary and higher education, although unofficially – is neither a local nor the first language to all students and their teachers. Swahili is therefore also a foreign language to most students and teachers in Tanzania, even though it is an African language.

A common argument has been that all the foreign languages of European origin were retained at independence as the official as well as classroom instruction languages for economic and political reasons. It is also an acceptable argument that the retention of the languages must have been dictated by circumstances that were prevailing at the time in the respective African countries. In the case of Kenya, although English was adopted on the recommendation of the first Education Commission, popularly known as the Ominde Commission, the logic may have been that at the time,

> "...English was [already established as] the language of the entire secondary education system, of university, in large part, of the press, and of many other sectors; it was also the language of much creative writing, and of effective public debate, whether in... scholarly writing and so on. It was for the time being, the main language of communication with outside ideas, whether in East or West, or indeed in other parts of Africa... not... that this was desirable or that it... be perpetuated or protected... this was a fact." (Ogot, 2003:171–172)

While the same argument may have been used in adopting French and Portuguese in the respective African countries at their attainment of independence, the case for Swahili in Tanzania was purely a political one. Arguably, the adoption of Swahili as the language of formal education in Tanzania in 1967, several years after independence, was so that the country became fully liberated from colonial influence (Kadeghe, 2003).

The current state of Swahili in Tanzania is such that the logic for the adoption of English in Kenya – as argued above by Ogot (2003), but in reference to Swahili – is very relevant. In other words, all arguments should be for the adoption of Swahili as the sole instructional language at all levels of education in Tanzania (Brock-Utne & Holmarsdottir, 2003; Brock-Utne, 2005; Prah, 2003; Roy-Campbell & Qorro, 1997). The global trends in the popularity of English (Newsweek, 2007) and the need for easy international communication would be the major issues in the ongoing debate for the need to adopt English instead as the instructional language at all levels of formal education in Tanzania.

In the African countries where English, French and Portuguese are already the languages of formal education, it is apparent that they may continue to be used at all professional and academic levels because of their global presence and attractiveness in international communication. With Swahili also being a generally foreign language to most Tanzanians, it follows that most students and their teachers in Africa will continue to use foreign languages as instructional languages in formal education. There is thus a requirement for students in African countries to achieve proficiency in whichever classroom language of instruction. This is a necessary first step for effective learning of school subjects to occur.

At least at the initial stages of learning, students in Africa will continue to experience greater difficulty than students who learn in their first languages. This is due to the double task of learning two new things – the language of instruction and, for example, science – at the same time. The learning of most school subjects, including science, requires more than simple proficiency in the language of instruction (Wilson, 1999), in spite of the assumption by many (including teachers) in multilingual societies that once proficiency in the instructional language has been achieved, students would be able to understand everything they are taught in that language (Rollnick, 1998, 2000).

In this article, the focus is on the instructional language as used by the *science teacher,* based on the role of language in all learning, including school science (Scott, 1998), and the now well-recognised need for teacher intervention in the learning of school science (Driver, 1989; Hodson & Hodson, 1998; Hodson, 1999). The article consists of three main parts. Firstly, the components and nature of the language of instruction as used in science texts and by science teachers in classrooms are discussed. Secondly, a critical review of research-based evidence of the possible universal difficulty of this language is presented. Thirdly, the approaches to working around the difficulty and foreignness of this language via, in particular, effective classroom use of language by science teachers and the necessary research on language in science education are considered.

The focus is particularly on science teachers' language, because the author regards the science teacher as the foremost resource in students' effective learning of science. However, based on the variety of resources or sources of school science knowledge available to the student, the term "science teacher" is considered to embrace and subsume the term "science texts" as a resource or an alternative source of the ideas of school science. Hence, *teachers' (classroom) language* as used in this article refers to the science teachers' oral language as well as the language of science texts, including that used in distance education material. Although the instructional language in particular focused on in this article is English, these discussions are meant to apply to any instructional language in use.

THE COMPONENTS AND NATURE OF SCIENCE TEACHERS' LANGUAGE

The instructional classroom language of the science teacher and science texts has two parts: a technical component and a non-technical component.

The technical component: The technical component is made up of technical words or terminologies specific to a science subject, for example, "chromosome" in Biology, "capacitance" in Physics, or "anion" in Chemistry. Such terms may also be referred to as technical terms, scientific terms or terminology, science terms or simply science words. Technical words, as originally argued by Gardner (1972), "...include such things as physical concepts (mass, force...) names of chemical elements, minerals, plants, organs, processes, apparatus etc." (p. 7). The technical or science words are everyday words deliberately used as science words (Miller, 1999), and they

have new (scientific) meanings in addition to their everyday meanings (Sutton, 1992; Wellington, 1994). The new, different meanings everyday words acquire when used as science words and/or when they become science words make them resemble words in a new, different or foreign language, although with fixed meanings. Regardless of the base language, the meanings of these words must be known in the international science community. Therefore, apart from representing science concepts (Murphy, 2002), science words are also representations of words in a different and/or foreign (science) language.

The non-technical component: The non-technical component of the science teacher's classroom language is made up of non-technical words. It is this part of the science teacher's classroom language that may be referred to as the medium of classroom instruction or interaction as separate from the technical terms. This component of the science teacher's classroom language thus becomes recognisable to be the same as the language in which a science textbook is written. Gardner (1972:7) used the following sentence to illustrate examples of non-technical words: "Gas molecules display random motion; we may predict their behaviour from theoretical considerations: the actual volume of the molecules may be neglected." Although they are not "technical terms", the four words "random", "predict", "theoretical" and "neglected" remain key words in the sentence with regard to the understanding of the behaviour of the gas molecules, on the assumption that the meaning of the (technical) term "molecule" is known to the learners. In science education research literature relevant to this article, it is words like these thathave been referred to as "non-technical words in the science context" (Wellington & Osborne, 2001). Apparently this has been done to distinguish them from the metarepresentational terms (Wilson, 1999) and logical connectives (Gardner, 1977), two other groups of words considered as distinct categories of non-technical words. The non-technical component of science classroom language of instruction and interaction, therefore, consists of three categories of non-technical words, namely non-technical words in the science context, metarepresentational terms and logical connectives. Highlighting the boundaries between these is of interest.

The "non-technical words in the science context", as part of the language typical of science subjects, may be considered to constitute a language characteristic of school science. For example, the word "diversity" is more common in Biology, "reaction" is more common in Chemistry than in Physics, and in a similar way, "disintegrate" would be more acceptable as a standard word when referring to the

concept of decay of an unstable nucleus in Physics. The words "diversity", "reaction" and "disintegrate" are recognisable as words also commonly used in everyday language, but become "specialist language" (Barnes, Britton & Rosen, 1986:46) only when used in science to constitute the register of the science subject. Each of these words embodies certain concepts important to the process of learning specific science subjects; this is unlike when everyday words are used as science words, when they become distinct science concepts as already considered here.

The *metarepresentational terms* in particular refer to the non-technical words that signify *thinking*; these include metalinguistic and metacognitive words as defined next. According to Wilson (1999:1069), "metalinguistic verbs are words which take the place of the verb to *say* (e.g. define, describe, explain, argue, criticise, suggest), while the metacognitive verbs are words which take the place of the verb to *think* (e.g. infer, calculate, deduce, analyse, observe, hypothesise, assume, predict)." Evidently, metarepresentational (metalinguistic and metacognitive words) terms constitute the same words that are associated with learning and "talking science" (Lemke, 1990), such as "observe", "hypothesise", "experiment", "classify", "analyse", "conclude", "deduce", "interpret", "define", "investigate" and "infer". It is these words, often used in examinations to indicate the content as well as the structure and emphasis required by the examination questions, that Bearne (1999:62) and Bulman (1986:188) have respectively recognised as the "key terms" or "operative words". Consequently, the value of these words is in the fact that knowledge of their meanings may enhance students' understanding of the demands of the questions and accordingly design the correct responses (Bulman, 1986). Students' understanding of the meanings of these words may also be expected to enhance their classroom participation (Rodrigues & Thompson, 2001).

According to Gardner (1977:v), *logical connectives* are "words or phrases which serve as links between sentences, or between propositions within a sentence, or between a proposition and a concept." Examples include "conversely", "if", "moreover", "because", "therefore", "in order to", "consequently", "by means of", "since", etc. The importance or functional value of logical connectives, as may be evident from these examples, is that they are words that, according to Fensham (2004:202), "are commonly used in the oral or written discourses of science to link observation to inference, theory to explanation, hypothesis to experiment, experiment to findings etc." Again, students' understanding of the meanings of these words would enhance their classroom participation as well as the understanding of the processes of learning science, including science teachers' classroom language.

GENERAL DIFFICULTY OF THE SCIENCE TEACHER'S LANGUAGE

Research studies have shown that all categories of words that comprise the science teacher's language are generally difficult.

Difficulty of words in the technical component of the classroom language

George (1999) recorded that the general difficulty of school science – hence, science content that is well known the world over – is that it varies in extent, depending on the specific circumstances in different countries. In this article, this general difficulty is argued on the foreignness of science words/language or technical terms used in science. While most arguments on the difficulty of school science have always made a claim on the difficulty of the science content matter, the foreignness of science to learners is also a very important factor, as can now be explained.

The fact that any science word has a meaning different to that in everyday language is one reason such words can be viewed as representations of a different, new or foreign language. The use of these words, therefore, comes with a way of speaking that is very uncharacteristic of the common or dominant culture. The science words and language therefore also represent a different culture – the (foreign) science subculture. Science words may therefore be considered to have a triple identity (conceptually, culturally and linguistically). The origin of the general difficulty of technical words interchangeably referred to as science words, science terminology or science content is this aspect of general foreignness. The foreignness of the science words may also explain the gap that exists between the students' world and the world of science they are meant to learn (Lemke, 1990; Jones, 2000).

Yet, this general difficulty of science words and content is only part of the difficulty of words that comprise the science teacher's instructional language. As revealed in the reviews of empirical research in the next section, all categories of non-technical words, just as the case with the science words, are also generally difficult. Evidence is presented that the general difficulty of non-technical words does not depend on the linguistic and cultural circumstances of the science learners.

Difficulty of words in the non-technical component of classroom language

In this section, a critical review of the general difficulty of all categories of non-technical words in the science teacher's language is conducted. The distinctive focus is on the influence of students' proficiency in the language of instruction (English) at the various levels of students' understanding of the words. This has been done in the order of non-technical words in the science context, metarepresentational terms and logical connectives.

a) Student difficulties with non-technical words in the science context

With regard to non-technical words used in the science context, there have been several cross-national studies, all of which have been based on Paul Gardner's pioneering study (Gardner, 1971). In this first project conducted in Papua New Guinea (Gardner 1971; 1972), Gardner studied the accessibility of 599 normal English words using a sample drawn from secondary school students in forms 1 to 4 for whom English was not their first language. Tests were administered in the form of multiple choice items (see Oyoo, 2009, for details on formats of representation of the test items). The study was not to compare, but only to detect the levels of difficulty the non-technical words presented to students of science. In the analysis, items were summarised in three ways:

- Alphabetical order: List contained all words tested in alphabetical order, with a brief description of the item, and the percentages correct for each form level and for the total sample.
- Level of difficulty: Words were grouped into difficulty levels based on the percentage correct in the total sample. Level 0 words were items on which the scores were 100% correct; level 1 words appeared in terms of which 90–100% were correct; level 2 words represented 80–89% correct and so on.
- Test item list: Presented all items used in the project: the percentages selecting each distracter within each form level and within the total sample were shown for each item.

In this first study, three words – "spontaneous", "disintegrate" and "random" – stood out as the most difficult for the students, especially for the form 1 students, with only 10–19% of the sample scoring correctly on these words. In summary, 31%, 26% and 25% of the entire sample scored correctly on the words "spontaneous", "disintegrate" and "random" respectively.

Two other studies by Gardner using the same design and for the same objectives were conducted using the same test items in Victoria, Australia (Gardner, 1972), and later in the Philippines (Gardner, 1976). While in both cases, participants were drawn from class levels/forms 1, 2, 3, and 4, all the participants in Victoria were science students who used English as their first language, while those who participated in the Philippines study were students who learned science in English as their second language. Both studies revealed similar trends in the understanding of the non-technical words, with differences that were a reflection of relative linguistic circumstances specific to each of the countries. If comparisons on the levels of performance were made, it could be concluded that the second-language sample (Philippines) performed poorer, i.e. encountered more difficulties with the non-technical words in the science context than the first-language sample (Victoria).

Although several subsequent studies have been conducted (Oyoo, 2004), only the studies of Farell and Ventura (1998), Prophet and Towse (1999) and Oyoo (2000) have not used the four-test design, or mainly English first-language (L1) samples. The above studies, on the other hand, focused on different categories of learners at different levels of schooling. Farrell and Ventura (1998), for example, focused on non-technical words as used in a specific school science subject – Physics. Prophet and Towse (1999) compared performance on these words in different countries and by first- and second-language learners simultaneously, drawn from a developing country (Botswana in Southern Africa) and a developed country (United Kingdom). The Oyoo (2000) study also drew its sample from both first- and second-language learners, but from Kenya and England (United Kingdom, UK).

In all the studies, the types and trends regarding students' difficulties with everyday words presented in the science context were very similar, irrespective of design and gender. The trends in the difficulties encountered by students further did not depend on whether a student learns science in English as a first or second language. A summary of the types of difficulties is as follows:

- Students selected words of which the meanings were opposite to those intended in the studies. For example, "negligible" for "a lot", "random" for "well ordered", "initial" for "final".
- For many words, the students lacked the required comprehension and often confused words with others in the same semantic field, e.g. "detect" with "project", "isolate" with "insulate", "reference" with "referred", "theory" with "fact" or "belief".

- It was also common for students to confuse words that were "graphologically" similar (Gardner, 1972), i.e. "look-alike" (Cassels & Johnstone 1985:14), or "phonetically" similar (Gardner, 1972), i.e. "sound-alike" (Cassels & Johnstone 1985:14), e.g. "complex" with "compound", "consistent" with "constituent", "component" with "opponent", "detect" with "protect"; "accumulate" with "accommodate"; "diagnose" with "diagonal"; "proportion" with "portion".

The study by Pickersgill and Lock (1991) detected no difference between the understanding of non-technical words in science by males and females and no difference between the verbal reasoning ability of males and females, but found a positive correlation between a student's score on a verbal reasoning test and on a test of understanding of non-technical words in science. The finding on verbal reasoning may be taken to imply that proficiency in the language of instruction may enhance the understanding of scientific concepts, but could also be a reflection of the different levels of intelligence and/or relative aptitude towards the subject. These explanations were not considered in the study. In all four-test format-designed studies, it was noticed that the best performance had been in the test where the words were presented in the science context and the lowest performance had been in the synonym test. Pickersgill and Lock (1991, p. 77), who used a first-language sample, explain this as follows:

> "... In the sentence, science and non-science format questions, the word under test is placed in a context which may carry sufficient information to give a cue or trigger to the student. In the synonym format, this information is missing and it may be the absence of such cues which leads to the poor performance on this type of question compared with others."

According to Marshall, Gilmour and Lewis (1991), the better performance in the test that had the words in the science context stem occurred because it is in the science context that the students first learnt the words; they conclude this by making comparisons with the Cassels and Johnstone (1985) study that used an exclusively first-language sample:

> "... although Cassels and Johnstone (1985) regard the words in this test as normal English, the results of this study indicate that for the Papua New Guinea students, this is probably not the case. For approximately 20 of the words, the results would seem to indicate that students acquired the meanings in science classes." (Marshall & Gilmour, 1991:334)

In the Marshall, Gilmour and Lewis (1991) study, an additional observation was that the words were easier when presented in the science context stem to students in Papua New Guinea, themselves English second-language learners, than was the case in the United Kingdom studies by Cassels and Johnstone (1980, 1985). This confirms that everyday words have different meanings when used in the science context. This may be justified by the fact that, although these studies claim an overall improvement in the relative scores in the higher (older) classes, a scrutiny of scores on the items does not reveal a linear trend. Scores on individual items were either better or worse in the higher or the lower class levels. The greater difficulty that the synonym-type test presented even to English first-language samples indicates that the non-technical words may not have been those common in the world outside the school (Ariza, Webb & Marinaccio, 2007; Mason & Mason, 1996; Rolstad, 2005).

b) Student difficulties with metarepresentational terms

No empirical study in the literature has specifically reported students' difficulties with metarepresentational terms. Reference to confusion caused by two everyday words, "describe" and "observe" (Cleghorn & Rollnick, 2002; Peacock, 1995; Clark, 1997), may be taken as evidence of the possible difficulty of the two words; "describe" and "observe" belong to this group of non-technical words. However, the difficulties students encounter with these terms may be argued on the fact that low outcomes in science examinations have been alleged to have their origin in students' poor understanding of these terms. Comments in the Kenya National Examinations Council (KNEC) Reports from 1990 to 2002 in the subjects Chemistry, Physics and Biology, for example, would suffice in this regard. In Kenya, English, a second language to learners and teachers alike, is used in all teaching and assessment. It is evident from the following comments that students' low outcomes in these subjects may, among other reasons, have been a consequence of their having encountered difficulties with the meanings of these words. Comments about poor performance in Chemistry papers revealed students' difficulties with the words "explain", "comment" and "describe":

> Teachers should make a deliberate effort to explain to their students what certain terminologies mean when used in questions. Such terminologies include "explain", "comment" and "describe". "This is because the kind of answers... indicated that the... candidates did not even understand what the questions were asking." (KNEC, 1992:97)

Students' difficulties with "define" and "distinguish" are suggested in the following comment on performance in the Physics examination question: "Distinguish between ductile and brittle material." As reported in KNEC (1990:41), "the candidates could only *define* the terms but could not *distinguish* between them. Teachers should teach the candidates to differentiate between the terms *distinguish* and to define and such other terms used in physics." Further evidence of student difficulty was reported with regard to "describe" and "account" in the 1997 and 1998 Biology examinations, where it was apparent that the students had encountered problems in the theory and practical papers because they lacked an adequate understanding of the meanings of the words. In Oyoo (2004:199), the following students' opinions are recorded in support of these reports.

> **Student 1:** "If you do not understand the meaning… of the words used in the topic … when these words are used in an exam, you will fail the paper because you do not know the word meanings."
>
> **Student 2:** "Lack of knowledge of the meanings of the words leads to time wastage during examinations because one takes a lot of time fumbling with the word meanings and then end up failing the exam just because of the meaning of a word."

In a first-language context, Rodrigues and Thompson (2001) report a teacher's reasons for explaining the meanings of these words to students during teaching based on the fact that otherwise, students would confuse the meanings of these words. Since confusion between the words has been a common source of students' difficulty with everyday words as already reviewed above, these words may also be difficult in first-language contexts.

c) Student difficulties with logical connectives

As Gardner (1977a:v) reports about the only major study conducted so far of students' difficulties with logical connectives, his was "a project set to identify the more commonly used logical connectives in science, and to measure junior secondary students' difficulties in comprehending the connectives". The connectives that emerged as difficult are the ones common in science texts and in science teachers' classroom talk (oral language). This is evident in the following groupings of related connectives (Gardner, 1977b:11):

- Several connectives that indicate inference are difficult: "and so", "consequently", "hence", "it follows that", "therefore", and "thus".
- A second group contains connectives involved in generalisations: "commonly", "frequently", "in general", "occasionally" and "often".
- Several difficult terms signal similarities, comparisons and contrasts: "alternatively", "as", "at the same time", "conversely", "in contrast", "in fact", "in turn", "much like", "nevertheless", "similar to", "similarly" and "unlike".
- Several apposition terms are difficult: "for instance", "i.e.", "in these examples", "namely", "that is" and "viz".
- Some students are unfamiliar with additive terms like "again", "also", "further", "furthermore", "in addition" and "moreover".

Overall, three connectives, "conversely", "if", and "moreover", were found to be extremely difficult (mean item facility at Form 4 less than 30%). Although the study used an English first-language sample, the emergence of a large number of difficult connectives implies that teachers' classroom language could be a challenge to all learners, irrespective of their linguistic backgrounds, if the connectives are used with no appropriate measures taken to assist students' understanding of them.

General difficulty of the science teacher's language – a summary and analysis

The general outcome of the review is that students encounter similar types and trends in difficulties with these words of the science teacher's language, irrespective of whether they are female or male (their gender). The types and trends of the difficulties encountered further do not depend on the students' linguistic circumstances, i.e. whether they learn science using their first language or not. The overall outcome of the review therefore is that the total language of instruction as may be used in science texts or by the science teacher (technical as well as non-technical words, as broadly defined in this article) presents difficulties to students, irrespective of their linguistic and cultural backgrounds.

In addition to students' difficulty with the words that have been referred to simply as non-technical words in the science context (Gardner, 1971), students also encounter difficulties with metarepresentational terms (metalinguistic and metacognitive words) and logical connectives. Despite the fact that these words

comprise the entire non-technical component of the classroom (English) language of instruction and interaction, this overall outcome has now made it more apparent that science teachers' language is generally a challenge to all learners. The extent of this challenge to students who learn in English as their second language may be dependent on the students' relative levels of general proficiency in the language of instruction. General proficiency in the language of instruction is a necessary first step for successful learning of science to occur in that language (Achebe, 1990).

Those who have to learn in a foreign language need some level of proficiency in the language of instruction as a prerequisite for all learning. The larger percentage of participant students in the studies reviewed for this paper had English as their first language. What has thus become apparent is that, generally, there is a need for caution in explaining students' difficulties in learning science on their perceived levels of proficiency in the language of instruction. The general difficulty of the science teacher's language in itself is therefore a strong support for the assertion that "everyday words when used in a science context cease to be mere English words" (Marshall & Gilmour, 1991:334). Consequently, what now needs to be emphasised, perhaps more than has been the case, is the fact that learners need to be appropriately and contextually proficient in the language of the science classroom.

The general difficulty of all categories of words in the language of the science teacher, whether written or oral, technical or non-technical, presents the linguistic face of the difficulty of school science. Drawing on the nature and functional value of these and other words that comprise the science teacher's language, it becomes apparent that there are other factors that influence students' understanding of these words, in addition to the students' proficiency in the (English) language of instruction. These words may also be representations of particular science subjects as well as embodiments of science concepts. Students' general ability or aptitude for science may also be expected to impact on the levels of understanding of the words.

ADDRESSING THE FOREIGN LANGUAGE PROBLEM IN SCIENCE CLASSROOMS

To reiterate, the role of language in all learning and the need for teacher intervention in the successful learning of school science (Driver, 1989; Hodson & Hodson, 1998; Hodson, 1999) are now well established. Language, either as text prepared or presented by the teacher or science teachers' own classroom

talk, is therefore unavoidable in learning science. We should expect that students' understanding of the meanings of all words in this language when used *as* science words and/or *in* science context would result in enhancing students' understanding or internalisation of the taught concepts. The appropriateness of this language to the level of schooling and general background of the learners (as the teacher may be expected to know) may therefore be of utmost importance.

Teachers' approach to classroom use of language as addressing the foreign language problem

Although teacher intervention in enhancing students' understanding of the technical/ science words, or science terminology, is what has often been regarded as science teaching, the general difficulty of science teachers' language has suggested the need for equal attention to the meanings of the non-technical words as broadly defined in this article. The difficulties students encounter with words that comprise teachers' language have suggested that aspects of teachers' approaches to the use of language in classrooms (vocabulary) may serve as major sources of students' linguistic difficulties when learning science. As implicit in the reviews of students' difficulties with words in science teachers' language, these include the need for checks on talking speed, pronunciation, audibility and language level (vocabulary). As becomes apparent from the discussions that follow, these aspects clearly form a necessary checklist for effective communication in classrooms, which should be generally observed by teachers. This is especially in light of the general difficulty of science teachers' language, as has now become apparent.

a) Speed of talking and pronunciation

A teacher's speed of talking may be a potential source of students' difficulties with learning, even in very well-planned lessons. Depending on students' ability and linguistic circumstances, teachers' fast speech may result in students not understanding or not recognising words used during teaching. The way in which words are pronounced during teaching is related to the speed of talking. While in fast speech words may not be pronounced clearly and/or correctly, incorrect pronunciation would possibly cause students to confuse these words with similar ones, or even fail to recognise the words altogether.

While this problem might be expected to occur only at lower school levels, the reviews presented in this article have revealed that confusion between words

due to how they are pronounced occurred even at pre-university level. The confusion was between the following words that sound alike: "consistent" and "constituent", "component" and "opponent", "detect" and "protect", "accumulate" and "accommodate", "diagnose" and "diagonal", "proportion" and "portion" (Cassels & Johnstone, 1985), "consistent" and "constant" and "parameter" and "perimeter" (Farrell & Ventura, 1998). Other examples include "simultaneous" and "instantaneous", and "spontaneous" and "simultaneous" (Oyoo, 2004).

b) Audibility

Word recognition may not be a problem only when the speed of talking is fast or words are pronounced poorly. This may also be the case if the talking is not clear or loud enough, as may be necessary in large class sizes characteristic of schools in some populations, or depending on teaching arrangements. As may be expected, students not yet comfortable with secondary school-level language of instruction or those yet to attain an appropriate level of proficiency in the language of instruction would be additionally disadvantaged by a teacher talking fast, poor pronunciation and inaudible speech.

c) Language level (vocabulary)

With regard to other components of teachers' classroom language, the use of vocabulary that is not appropriate for the levels they are teaching may result in students' difficulties with the classroom language. Logical connectives, for example, may be especially difficult for many students. As pointed out here, the only study so far of students' difficulties with these words involved only first-language learners (Gardner, 1977a). Hence, it can be expected that students who learn in a second or foreign language, and perhaps with different and possibly lower levels of proficiency in the instructional language, would have more problems with these words. What may be considered an obvious implication of this is that teachers' classroom language could be a greater challenge to the learners who learn in a second or foreign language, depending on their levels of proficiency in the language.

The importance of metarepresentational terms in examinations, as already pointed out in this article, highlights the need for learners to possess a good understanding of the meanings of these words. The difficulty of these words, particularly during examinations, assessments or in solving problems (Bulman, 1986), may therefore be expected if science teachers do not emphasise their meanings during teaching.

Explicit or implicit use or reference to terms in particular may be sources of students' difficulties with the content of lessons and even assessment tasks. It is important to note that although science teachers would only use metarepresentational terms when solving numerical questions (problems), metacognitive and metalinguistic words, they would minimally explain the words' meanings (Oyoo, 2006). However, with regard to making explicit or implicit references to these words, teacher sensitivity to students' language difficulties may need to be judged on individual students' circumstances. The implication of this for teachers is that they need to carefully consider when to make explicit or implicit references to words during their teaching (Wilson, 1999).

In addition to the approaches so far suggested, different approaches may be necessary, depending on teachers' levels of knowledge and sensitivity to students' general learning needs, including linguistic competence. The most important argument for the need for attention to how science teachers use language has been based on the nature and functional value of each category of the words that make up the language as used in science texts and by science teachers. Apart from some of these words being themselves science concepts, others are representations of particular science subjects. Yet, some of them embody science concepts as well as concepts necessary for the understanding of the processes of learning science, for example "filtration", "distillation" etc. Arguably, no word should be avoided during teaching, for the simple fact that:

> "... the learners are progressing with the learning and will most likely meet the same words at a higher level. The teachers should just uplift the level of vocabulary of the students. They should explain the meanings of these difficult words whenever they are used in class to avoid confusion in the understanding by the students." (Oyoo, 2004:203)

While this opinion may be considered with reference to the entire non-technical component of the classroom language, it is generally applicable to circumstances where learning is in a language other than the learner's first language. It is also generally applicable to circumstances where the learners' levels of proficiency in the instructional language are perceived to be lower than may be the appropriate standard for the school level. The benefit of this approach is in the fact that students' competence in the instructional language will facilitate their understanding of the taught concepts. Another argument (reproduced immediately below) represents the often-neglected voice of the student – the main stakeholder in all teaching.

The argument is in favour of non-avoidance of any words, including those deemed difficult. Learning the meanings of difficult words would also perhaps enhance their subject-related self-esteem.

> "Student: We also should know the difficult words relevant to the subject so that when we meet the words, like "anomalous" then we just know that it is [means] "unusual". So the teacher should provide the other possible meanings and this should be all the time." (Oyoo, 2004:204)

The implication for teachers is that they need to have good mastery of subject matter content, vocabulary in the language of the classroom, and the learning context, including the learners' cultural backgrounds. The non-technical words are generally unavoidable in the characteristic teachers' classroom talk and students may generally not be expected to discover the meanings of these on their own. This is especially argued based on 1) the possible changeability of the meanings of words used in the instructional language depending on the context of use, and 2) the fact that the meanings of science words must be known in the science education community circles. Teachers also need to observe the triple identity of the science words to be able switch between these during their offering of explanations in the classrooms. While teachers should be well aware of these issues, more information need to be sourced via more research, as discussed in the next and last major section of this article.

Further and new focus in science education research as addressing the problem

This review has explicitly laid out the general difficulty of all words that comprise the *language of instruction* typical of science classrooms and texts, an outcome that may have conveyed the reality of the centrality of the language of instruction to science learning. As argued at the beginning of this article, 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. Further, interpretations of the findings in studies in this area (Peacock, 1995; Peacock, Cleghorn & Mikkila, 2002) have been conducted to benefit the improvement of science texts as learning resources for primary science. The teacher, as the foremost learning resource in school science at all levels, and teachers' instructional language as a tool have been out of general focus in international science education research. Hence, an urgent need exists for more research on the manner in which science teachers use the

language of instruction in classrooms, with an emphasis on how this may influence students' understanding and retention of science concepts via enhanced knowledge of word meanings. The role and place of language in all learning (Vygotsky, 1986) is now well established. The need for this new focus in science education research is justifiable, based on the need for teacher intervention in the learning of science and everyday words when used in the scientific context.

A focus on teachers' classroom use of language is now generally urgent, including in countries where non-English language background (NELB) learners are in the minority (Ariza, Webb & Marinaccio, 2007). In such countries, the teaching of science has continued with the expectation that students will understand and learn when teachers present the content in scientifically appropriate ways. In other words, there has been little consideration for these students' literacy, language, and cultural understanding (Lee & Fradd, 1998). While this tendency might be responsible "in part for the under-representation and alienation of diverse students in science" (p. 13) in these countries, similar assumptions in the countries where students learn in a second or an additional language may have adversely impacted on levels of students' outcomes and attitudes towards science.

Based on the observed similarities in the classroom language use of science teachers, more studies on the impact of teacher intervention in enhancing students' understanding of language in the science classroom may be justifiable. Although literature in this area is still scanty as observed so far (Yore & Treagust, 2006; Yore, Hand & Bisanz, 2003), there is adequate evidence in the few reports in circulation on teachers' classroom approaches to science teaching.

In the Bleicher, Tobin and McRobbie (2003:234) study of experienced teachers in Australian and American contexts, for example, the teacher participant clearly controlled "the discourse in a linear, unyielding one-dimensional push to reach a satisfactory conclusion to cover the topic of the day". In the same study during a follow-up interview, the students as well as the teacher indicated that they preferred the approach. The reason was that it led to the completion of the syllabus in time and would be a window on the constraints on effective practice teachers face in classrooms.

The presentations by Ogborn, Kress, Martins and McGillicuddy (1996) of teachers' approaches to explaining science in classrooms may be examples of science teachers' approaches found in the United Kingdom (Yandell, 2003). They may

also be examples of science teachers' approaches in any other country. Abagi, Cleghorn and Merritt (1988), Cleghorn, Merritt and Abagi (1989), Cleghorn (1992), Cleghorn and Rollnick (2002) and Abdi-Kadir and Hardman (2007) would present the situation in primary school science classrooms in Kenyan and South African contexts in particular, as well as in classrooms where English is a second language to both students and their teachers. More research will have to be based on the recognition of the triple identity of the nature of science words and concepts, and should be based on the following three issues:

- Recognition of the science teacher as the foremost resource in learning science (Driver, 1989)
- The general purposes of teacher use of language in science classrooms (Scott, 1998)
- The greater percentage of talk in many classrooms, including those of science, across a wide range of teachers and across countries, comprises that of the teacher (Barnes et al., 1986; Barnes & Todd, 1995; Edwards & Mercer, 1987; Wilson, 1999; Bleicher, Tobin & McRobbie, 2003)

This commonality in science teachers' classroom approaches may offer more support for the argument for more research in teachers' use of instructional language in classrooms. The general existence of science teachers' classroom approaches to classroom talk serves to challenge any assumptions about the existence of culturally determined approaches to the teaching of school science.

CONCLUSION

In contexts where most formal education is conducted in instructional languages, usually foreign to most learners and even the teacher, the impact of language on learning is not new. However, the attention that has been given to the language of instruction has been with regard to the need to make learners proficient in it; hence, the apparent assumption that once proficiency has been achieved in the instructional language, the students would just understand the words' meanings. This may be evidence of the possibility that communicating objective knowledge by means of language has traditionally been taken for granted by educators (Von Glasersfeld, 1998). While proficiency in the language of instruction is necessary for social interaction in the classrooms, learning science involves more than mere social interaction; it also involves deliberate formulation and sharing of ideas (Wilson, 1999). Therefore, the instructional language needs to be appropriate in all respects.

It thus becomes apparent why even students who have attained acceptable levels of proficiency in the language of instruction have often been found unable to follow classroom discussions with "good" science teachers. In many cases, this occurs when both the learner and the teacher know the meaning of a word (e.g. everyday word used in science context or as a science word) and each assumes that the other shares the same meaning. The consequence has been breaks in communication, poor understanding of the scientific concepts, and poor science outcomes.

Although it has been possible to educate science teachers on the contemporary effective teaching approaches for enhanced learning in science, the role of language of instruction has not really been a focus area. This is because 1) post-colonial practices linked to formal examinations and teacher training practices based on old models (personal communication), and 2) the education of science teachers in Africa have often depended on research findings in (English) monolingual societies – mainly Australia, the United Kingdom and the United States of America – to inform local approaches on how teachers are prepared. In these monolingual societies, the identity of the language of instruction has mainly been taken as static; hence an existence of unawareness of how words have different meanings when used in different contexts. Despite the larger volume of research in these societies so far (Fensham, 2004; Harlen, 1999), studies on language for effective science education may only be beginning to consider the impact of the language of instruction on enhanced learning in science classrooms (Kinchin, 2005; Yandell, 2003).

In this article, the objective has been to suggest an approach to the use of language by science teachers appropriate to the general international science education community, which may lead to an enhanced understanding of the scientific concepts. It will be of particular relevance to contexts where science is learnt in a foreign language (such as in all countries in Africa) because of the language proficiency requirement as a necessary first step in learning in that language. The need to ensure that the language for learning is appropriate to the context of use also makes this article relevant to developers of science texts for classroom use as well as distance education material. This article is the outcome of sustained literature reviews of cross-national research and the view of science as a distinct language, foreign to all learners irrespective of their first language. The outcome of this review has apparently strengthened the need to recognise an instructional language as an appropriate technology (Oyoo, 2008) in spite of any foreignness of the language.

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