**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 education is conducted in instructional languages that are foreign to most learners and their teachers. 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, which may lead to learners' enhanced understanding of the scientific concepts towards enhanced outcomes. 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 including it being a distinct language, foreign to all learners irrespective of their first language is adopted. It is intended to be of particular relevance to contexts where formal learning in science is conducted in a foreign language because of the language proficiency requirement as a necessary first step in learning in that language. However, due to the global trends in immigration, the popularity of English, as the preferred classroom language of instruction, especially how the language of instruction changes when used in the science context, and the adopted view of science as a distinct language, this article is of relevance to the general international science education community. The main objective in this article is therefore to foreground the role of the instructional language as used by the science teacher. This article particularly targets the science teacher within the well known need for teacher intervention in the learning of school science.*

## 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)

In spite of UNESCO's assertion that educating learners in a language that 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, to refer 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', for the special reason that Swahili, the mandatory language of primary school education but - though unofficially - also used widely in secondary and higher education, is neither a local language nor the first one to all students and their teachers. Swahili is therefore also a foreign language to most students and teachers in Tanzania; it however 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 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, pp. 171 – 172; italics my addition)

While this 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, 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 as so far presented, for adoption of English in Kenya, but in reference to Swahili is very relevant. In other words, all arguments should be for 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, August 20/27, 2007) and 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 even 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. Hence, the requirement for the students in African countries to achieve proficiency in whichever is the classroom language of instruction, as a necessary first step for effective learning of school subjects to occur will continue. More than students who learn in their first languages therefore, and at least at the initial stages of learning, students in Africa will continue to experience greater difficulty due to the double task of learning two new things - language of instruction and for example, science - at the same time. Despite the assumption by many (including teachers) in multilingual societies, that once proficiency in the instructional language has been achieved, then students' would be able to understand everything taught them (Rollnick, 1998, 2000), learning of most school subjects, including science requires more than simple proficiency in the language of instruction (Wilson, 1999). 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 (Vygotsky, 1986) including school science (Scott, 1998) and the now well recognized need for teacher intervention in the learning of school science (Driver, 1989; Hodson & Hodson, 1998; Hodson, 1999). The article is in 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 possible universal difficulty of this language is presented. Thirdly, the approaches to going round the difficulty and foreignness of this language via, in particular, effective classroom use of language by science teachers and necessary research on language for/in science education are considered. The particular focus on science teacher's language is because this 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 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, *teacher's (classroom) language* as used in this chapter refers to the science teacher's oral language as well as the language of science texts. Although the instructional language in particular focus in the discussions in this chapter is English, these discussions are meant to generally apply to any instructional language in use.

## The Components and Nature of Science Teachers' Language

The classroom instructional language the science teacher and in science texts has two parts: technical component and 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/ 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/science words are everyday words deliberately used *as* science words (Miller, 1999) and have new (scientific) meanings in addition to their every day meanings (Sutton, 1992; Wellington, 1994). The new and 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, though with fixed meanings. Regardless of the base language, the meanings of these words must be as known in the international science community circles. 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 teachers' classroom language is made up of non-technical words. It is this part of the science teachers' 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 teachers' classroom language thus becomes recognisable to be the same as the language in which a science text book is written. Gardner (1972) used the following sentence to illustrate examples of non-technical words: that "gas molecules display *random* motion; we may *predict* their behaviour from *theoretical* considerations: the actual volume of the molecules may be *neglected*" (p. 7). The four words: *random, predict, theoretical* and *neglected*, though not 'technical terms', 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 that in particular, have been referred to as 'non-technical words in the science context' (Wellington & Osborne, 2001). This apparently has been to distinguish them from the metarepresentational terms (Wilson, 1999) and logical connectives (Gardner, 1977), two other groups of words, considered here as distinct categories of non-technical words. The non-technical component of science classroom language of instruction/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 in chemistry than in physics, just 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 recognizable as words also commonly used in everyday language, but become "specialist language" (Barnes, Britton & Rosen, 1986, p. 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* specifically, refer to the non-technical words that signify *thinking*; these include metalinguistic and metacognitive words as defined next. According to Wilson (1999), "metalinguistic verbs are words which take the place of the verb to *say* (e.g. define, describe, explain, argue, criticize, suggest), while the metacognitive verbs are words which take the place of the verb to *think* (e.g. infer, calculate, deduce, analyse, observe, hypothesize, assume, predict)" (p. 1069). Evidently, metarepresentational (metalinguistic and metacognitive words) terms constitute the same words which are associated with learning and 'talking science' (Lemke, 1990), such as *observe, hypothesize, 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, p. 62) and Bulman (1986, p. 188) have respectively, recognised as the "key terms" or "operative words". The

value of these words therefore is in the fact that knowledge of their meanings may enhance students' understanding of the demands of the questions and to 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).

*Logical connectives*, according to Gardner (1977), are "words or phrases which serve as links between sentences, or between propositions within a sentence, or between a proposition and a concept" (p. v). 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), "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" (p. 202). 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 entire/total science teacher's language are generally difficult.

### Difficulty of Words in the Technical Component of the Classroom Language

George (1999) has recorded that the general difficulty of school science, hence science content as is well known world over, vary 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 of 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 very uncharacteristic of the common/dominant culture; the science words/language therefore also represents a different culture – the (foreign) science subculture. Science words may therefore be considered to have a triple identity (conceptual, cultural and linguistic). 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/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 like with the science words, are also generally difficult; evidence is presented that the general difficulty of non-technical words is irrespective of the linguistic and cultural circumstances of the science learners.

### Difficulty of Words in the Non-Technical Component of the 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, with the distinctive focus on the influence of students' proficiency in the language of instruction (English) on levels of students' understandings of the words is conducted. This has been done in the order, non-technical words in the science context, metarepresentational terms and logical connectives.

#### *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 pioneer study (Gardner, 1971). In

this first project that was conducted in Papua New Guinea, (Gardner 1971, 1972), Dr. Paul Gardner studied the accessibility of 599 normal English words using a sample drawn from secondary school students in Forms 1- 4 for whom English was not the 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 just to detect levels of difficulty the non-technical words presented to students of science. In the analysis, items were summarised in three ways:

- Alphabetical order: list containing 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 on the basis of 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 on 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 distractor within each form level and within the total sample were shown for each item.

In this first study, three words: *disintegrate, random* and *spontaneous* stood out as the most difficult to the students, more to the Form One students with only 10-19% of the sample scoring correctly on these words. As a summary, 31%, 26% and 25% of the whole 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 I, II, III, and IV, all the participants were science students who used English as their first language in the case of Victoria, 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) did 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), the only Farell and Ventura (1998), Prophet and Towse (1999) and Oyoo (2000) studies have not used the four-test design, or mainly English first language (L1) samples. The Farrell and Ventura (1998), Prophet and Towse (1999) and Oyoo (2000) 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).

The types and trends in the findings in all the studies of students' difficulties with every day words presented in the science context have been very similar irrespective of design and gender. The trends in the difficulties encountered by students have also been regardless of whether a student learns science in English as the first or second language. A summary of the types of difficulties is now provided,

Students selecting words whose 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 that students confused words with 'graphologically' similar (Gardner, 1972), i.e. 'look-alike' (Cassels & Johnstone 1985, p. 14) or 'phonetically' similar (Gardner, 1972), i.e. 'sound-alike' (Cassels & Johnstone 1985, p. 14), ones 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; 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, 1) may be taken to imply that proficiency in the language of instruction may enhance better understanding of scientific concepts; 2) 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 the four-test format designed studies, it was noticed that the best performance has been in the test where the words were presented in the science context and the lowest performance was on the synonym test. Pickersgill and Lock (1991, p. 77) who used a first language sample have explained 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 was because it is in this science context that the students first learnt the words; they concluded 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, p. 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 in 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 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).

***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; *describ*e 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 its origin in students' poor understanding of these terms. Comments in the Kenya National Examinations Council (KNEC) Reports of 1990 through 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. Evident in the following comments, students' low outcomes in these subjects may, among other reasons, have been consequent on their having encountered difficulties with the meanings of these words. Comments about poorly performed chemistry paper revealed students' difficulties with the words: *explain, comment, 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, describe* etc. This is because the kind of answers … indicated that the…candidates did not even understand what the questions were asking. (KNEC 1992, p. 97)

Students' difficulties with *define* and *distinguish* are suggested in the following comment on performance on the physics examination question: *Distinguish between ductile and brittle material*. As reported in KNEC (1990), "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 (p. 41). Further evidence of student difficulty was reported with regard to *describe* and *account* on the 1997 and 1998 biology examinations, where it was apparent 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, p. 199), the following students' opinions have been recorded in support of these reports.

> **Student 1:** If you don't 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) have reported a teacher's reasons for explaining the meanings of these words to students during teaching on the basis of the fact that otherwise, students would confuse between 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.

***Student Difficulties with Logical Connectives***

As Gardner (1977a) 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" (p. v. 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).

> Several connectives which 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 IV less than 30 per cent).

Gardner (1977b, p. 11)

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 the connectives.

**General Difficulty of the Science Teachers' 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 teachers' language irrespective of whether they are females or males (their gender). The types and trends of the difficulties encountered are also irrespective of 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), present difficulties to students irrespective of their linguistic and cultural backgrounds. In other words, in addition to the difficulty to students of 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/interaction, this overall outcome has now made it more apparent that science teachers' language is generally a challenge to the 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, for successful learning of science to occur is a necessary first step for meaningful learning in that language (Achebe, 1990).

The need for some level of proficiency in the language of instruction as a prerequisite for all learning, by those who have to learn in a foreign or second language therefore need not be overemphasised. Since the larger percentage of participant students in the studies reviewed here had English as their first language, what has now become apparent is that generally, there is 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 teachers' language in itself is therefore a strong support for the assertion that "every day words when used *in* a science context cease to be mere English words" (Marshall & Gilmour, 1991, p. 334). Consequently, what now needs to be emphasised, perhaps more than has been the case, is the fact that that learners need to be appropriately/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 therefore 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 teachers' language, it becomes apparent there are other factors that influence students' understanding of these words in addition to the students' proficiency in the (English) language of instruction. Especially on the already fact that 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 (Vygotsky, 1986) and the need for teacher intervention in 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 enhanced students' understanding or internalisation of the concepts taught. 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 the science teachers' language has suggested the need for equal attention to the meanings of the non-technical words as broadly defined in this chapter. The types of difficulties students encounter with words that comprise the teachers' language have suggested aspects of teachers' approaches to use of language in classrooms (vocabulary) that, though may not be receiving explicit attention, 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, the classroom steps include need for checks on talking speed, pronunciation, audibility and language level (vocabulary). As becomes apparent from the discussions of these that follow, these aspects clearly form a necessary checklist for effective communication in classrooms to be generally observed by teachers. This is especially in light of the general difficulty of the science teachers' language as has now become apparent.

*Speed of talking and pronunciation*

A teachers' 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 recognizing words used during teaching. Related to the speed of talking is the way words are pronounced during teaching. While in fast speech words used may not be pronounced distinctly and/or correctly, incorrect pronunciation would possibly make students to confuse these words with similar ones, or even fail to recognize 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 fact that confusion between words due to how these are pronounced happened even to pre-university level students; this was between the following sound alike words: *consistent* with *constituent*, *component* with *opponent*, *detect* with *protect*; *accumulate* with *accommodate*; *diagnose* with *diagonal*; *proportion* with *portion* (Cassels & Johnstone 1985), and *consistent* with *constant* and *parameter* with *perimeter* (Farrell & Ventura 1998). Other examples include *simultaneous* and *instantaneous*, and *spontaneous* and *simultaneous* (Oyoo, 2004).

*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 talk is not clear or loud enough as may be particularly 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 yet to attain appropriate level of proficiency in the language of instruction would be additionally disadvantaged by a teacher's fast talk, poor pronunciation and inaudible speech.

*Language level (vocabulary)*

With regard to other components of teacher's classroom language, teachers' use of vocabulary not appropriate to the levels they are teaching may result in students' difficulties with the classroom language. Logical connectives, for example, may be especially difficult to many students. As so far pointed out here, the only study so far of students' difficulties with these words, had only first language learners (Gardner, 1977a). Hence, it can be expected that students who learn in a second/foreign language, and perhaps of 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/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 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 emphasize the meanings during teaching. In particular, explicit or implicit use or reference to terms 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 use metarepresentational terms - metacognitive and metalinguistic words – only when solving numerical questions (problems), they would only minimally explain the words' meanings (Oyoo, 2006). However, teacher sensitivity to students' language difficulties while learning science, with regard to making explicit or implicit references to these words may need to be judged on individual student's 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 here, 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 together make up the language as used in science texts and by the 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, therefore, 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, p. 203)

While this opinion may be considered in reference to the entire non-technical component of the classroom language, it is generally applicable to circumstances where learning is in a foreign 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 concepts taught. Another argument (reproduced immediately below) represents the often-neglected voice of the student – the main stakeholder in all teaching - in favour of non-avoidance of any words, including those deemed difficult. Learning the meanings of difficult words also, would 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, p. 204; my addition)

The implication on teachers is that they need to be vast in the subject matter content and vocabulary in the language of the classroom as well as of 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. The teachers also need to observe the triple identity of the science words so as to be able switch between these during heir 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 chapter.

**Further and New Focus in Science Education Research as addressing the problem**

This review has explicitly laid out the fact of 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 his article, the attention that has been given to language issues in learning of science has in the main been with regard to the learners' proficiency in the language. Further, interpretations of the findings in studies in this area (Peacock, 1995; Peacock, Cleghorn & Mikkila, 2002) have been with a view 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 teacher's instructional language as a tool have been out of general focus in international science education research. Hence, an urgent need exists for new focus in and more research on the manner of science teachers' use of 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, and the need for this new focus in science education research is justifiable on the need for teacher intervention in learning of science and everyday words when used in the science context as has been argued.

A focus on teachers' classroom use of language is now argued to be 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 gone on 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 on 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. The argument here for the general need for more studies on the impact of the manner of teacher intervention in enhancing students' understandings of the language of the science classroom hence science concepts, may be justifiable on the observed similarities in science teachers' classroom approaches including use of words/language. Although literature in this area is still scanty as so far observed (Yore & Treagust, 2006; Yore, Hand & Bisanz, 2003) there is adequate evidence in the few reports so far in circulation regarding teachers' classroom approaches during science teaching.

In the Bleicher, Tobin and McRobbie (2003) 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" (p.234). In this same study, that the students as well as the teacher indicated in a follow-up interview that they preferred the approach since it led to the completion of the syllabus in time would be a window into the constraints to effective practice teachers face in classrooms. While the elaborate presentations of teachers' approaches to explaining science in classrooms by Ogborn, Kress, Martins and McGillicuddy (1996) may be considered specific examples of science teachers' approaches found in the United Kingdom (Yandell, 2003), they may be recognized to represent examples of teachers' approaches in explaining science in any other country of the world today. Abagi, Cleghorn & Merritt (1988); Cleghorn, Merritt & Abagi (1989), Cleghorn (1992); Cleghorn & 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. The need for more research will need to be based on recognition of the triple identity of the nature of science words/concepts, and be founded on the following three issues. Firstly, recognition of the science teacher as the foremost resource in learning science (Driver, 1989); secondly, the general purposes of teacher use of language in science classrooms (Scott, 1998). Thirdly, the fact that 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 be more support for the argument for more research in the 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 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 then the students' meanings would just come through. 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). The instructional language needs therefore to be appropriate in all respects. The reason 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 of science thus becomes apparent. 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 been really a focus. This is because education of science teachers in Africa has often depended on research findings in (English) monolingual societies – mainly Australia, United Kingdom and United States to America - to inform local approaches to how we prepare our teachers. In these monolingual societies, the identity of language of instruction has in the main, been taken as static, hence an existence of unawareness of . Hence, despite the larger volume of research in these societies so far (Fensam, 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 (like is the case in all countries in Africa including South Africa) because of the language proficiency requirement as a necessary first step in learning in that language. This article is the outcome of sustained literature reviews of cross-national research and the distinctive view of science as a distinct language, foreign to all learners irrespective of their first language, indeed an appropriate technology (Oyoo, 2008).

**References**


Abagi, J., Cleghorn, A. & Merritt, M. (1988). Language use in standard three: Science instruction in urban and rural Kenyan schools. *Kenya Journal of Education*, 4 (1), pp. 118 – 145.

Abdi-Kadir, J. & Hardman, F. (2007). The Discourse of Whole Class Teaching: A Comparative Study of Kenyan and Nigerian Primary English Lessons. *Language and Education*, Vol. 21 (1), pp. 1 – 15.

Achebe, C. (1990). What Has Literature Got to Do with It? In C. Achebe, *Hopes and Impediments: Selected Essays*, pp. 154 – 170. New York and Toronto: First Anchor Books Edition, October 1990.

Ariza, E. N. W, Webb, E. & Marinaccio, P. S. (2007). Teaching Academic Content to Second Language Learners. *The International Journal of Learning*, 14 (4), pp. 85 – 92.

Barnes, D. & Todd, F. (1995). *Communication and learning Revisited: making meaning through talk.* Portsmouth, NH: Boynton/Cook Publishers Heinemann.

Barnes, D. (1976). *From Communication to Curriculum*. Harmondsworth, Middlesex, England: Penguin Books.

Barnes, D., Britton, J. & Rosen, H. (1969). *Language, the learner and the School*. Harmondsworth: Penguin.

Barnes, D., Britton, J. & Torbe, M. (1986). *Language, the learner and the school*, 3rd (New) edition. Harmondsworth, Middlesex, England: Penguin Books Ltd.

Bearne, E. (1999) (Ed). *Use of Language across the Secondary Curriculum*. London: Routledge.

Bleicher, R. E., Tobin, K. & McRobbie, C. J. (2003). Opportunities to Talk in a High School Chemistry Classroom. *Research in Science Education*, 33 (3), pp. 319 – 339.

Brock-Utne, B. (2005). Language-in-education policies and practices in Africa with special focus on Tanzania and South Africa – insights from research in progress. In J. Zajda (ed.), *International Handbook on Globalisation, Education and Policy Research*, pp. 549-565. Dordrecht, The Netherlands: Springer

Brock-Utne, B. and Holmarsdottir (2003). Language policies and practices – some preliminary results from a project in Tanzania and South Africa. In B. Brock-Utne, Z. Desai and M. Qorro (eds) (2003), *Language of instruction in Tanzania and South Africa (LOITASA)*, pp.80 – 101. Dar es Salaam: E & D Limited.

Brock-Utne, B., Desai, Z. and Qorro, M. (eds) (2003). Introduction. In B. Brock-Utne, Z. Desai and M. Qorro (eds) (2003), *Language of instruction in Tanzania and South Africa (LOITASA)*, pp. 1 – 14. Dar es Salaam: E & D Limited.

Bulman, L. (1988). *Teaching language and study skills in secondary science*. London: Heinemann Educational Books.

Cassels, J. R. T. & Johnstone, A. H. (1980). *Understanding of Non-Technical Words in Science.* London: Royal Society of Chemistry.

Cassels, J.R .T. & Johnstone, A. H. (1985). *Words that Matter in Science.* London: Royal Society of

Chemistry.

Clark, J. (1997). Beyond the turgid soil of science prose: STAP'S attempt to write more accessible science text materials in general science. In M. Saunders (Ed.), *Proceedings of the Sixth Annual Meeting of the Southern African Association for Research in Science and Mathematics Education*, Johannesburg, South Africa: University of the Witwatersrand, pp. 390 – 396.

Cleghorn, A. & Rollnick, M. (2002). The Role of English in Individual and Societal Development: A View From African Classrooms. *TESOL QUARTERLY*, 36 (3), Autumn 2002, p. 347 – 372.

Cleghorn, A. (1992). Primary level science in Kenya: constructing meaning through English and indigenous languages. *International Journal of Qualitative Studies in Education*, 3 (4), pp. 311-323.

Cleghorn, A., Merrit, M. & Abagi, J. O. (1989). Language Policy and Science Instruction in Kenyan Primary Schools. *Comparative Education Review*, 33 (1), pp. 21-39.

Department of Education & Science. (1989). *Report of the English working Party 5-16 (Cox Report)*. London: Her Majesty's Stationery Office.

Driver, R. (1989). Changing conceptions. In P. Adey, J. Bliss, J. Head, and M. Shayer (Eds.), *Adolescent development and school science*. Lewes, UK: Falmer Press, pp.79-99.

Edwards, D. & Mercer, N (1987). *Common Knowledge: the Development of Understanding in the Classroom*, London: Routledge.

Farell, M. P. & Ventura, F. (1998). Words and Understanding in Physics, *Language and Education*, 12 (4), p.243-54.

Fensham, P. J. (2004). *Defining an Identity: The Evolution of Science Education as a Field of Research*. Dordrecht/London/Boston: Kluwer Academic Publishers.

Gardner, P. L. (1971). *Project SWNG – Scientific Words: New Guinea.* Melbourne: Faculty of Education, Monash University.

Gardner, P. L. (1972). '*Words in Science': An Investigation of Non-Technical Vocabulary Difficulties Amongst Form I, II, III and IV Science Students in Victoria*. Australian Science Education Project: Melbourne.

Gardner, P. L. (1974). Language difficulties of science students, *Australian Science Teachers Journal*, 20(1), pp. 63-76.

Gardner, P. L. (1976). *Project WISP – Words in Science: Philippines*. Melbourne: Faculty of Education, Monash University.

Gardner, P. L. (1977a). *Logical Connectives in Science: An investigation of difficulties in comprehending logical connectives in both scientific and everyday contexts amongst junior secondary school students in Victoria.* Melbourne: Faculty of Education, Monash University.

Gardner, P. L. (1977b). Logical Connectives in Science: A Summary of the Findings. *Research in Science Education*, 7, pp. 9 - 24.

George, J. (1999). WorldView Analysis of Knowledge in a Rural Village: Implications for Science Education. *Science Education*, 83 (1), pp. 77-96.

Glasersfeld. E. von, (1998) 'Cognition, Construction of Knowledge and Teaching.' In M. R. Matthews (Ed), *Constructivism in Science Education*, pp. 11-30. Dordrecht: Kluwer Academic Publishers.

Global Education: The race is on - rivalry among top schools is fiercer than ever and the West may be losing its lead. (2007, August 20/August 27). *Newsweek* (Special Double Issue) pp. 38 – 67.

Harlen, W. (1999). *Effective Teaching of Science: a review of research*. Edinburgh: Scottish Council for Research in Education.

Hodson, D & Hodson, J. (1998). From constructivism to social constructivism: a Vygotskian perspective on teaching and learning science, *School Science Review*, 79, (289), pp.33-41.

Hodson, D. (1999). Going Beyond Cultural Pluralism: Science Education for Socio-political Action. *Science Education*, 83 (6), pp.775-796.

Jones, C. (2000). The role of Language in Learning and Teaching of Science. In M. Monk and J. Osborne (eds), *Good Practice in Science Teaching: What research has to say*, p.88 - 103. Buckingham, Philadelphia: Open University Press.

Kadeghe, M. (2003). In Defence of Continued Use of English as the Language of Instruction in Secondary and Tertiary Education in Tanzania. In B. Brock-Utne, Z. Desai & M. Qorro (eds), *Language of Instruction in Tanzania and South Africa (LOITASA)*, pp. 170 – 186.Dar es Salaam: E & D Limited.

Kenya National Examinations Council (1992). *1990 KCSE Examination Candidates Performance Report*. City Square, Nairobi: Kenya National Examinations Council, pp. 28 - 80.

Kenya National Examinations Council (1994). *1991 and 1992 KCSE Examination Candidates Performance Report*. City Square: Nairobi: Kenya National Examinations Council, pp. 51 – 136.

Lee, O. & Fradd, S.H. (1998). Science for All, Including Students From Non-English-Language Backgrounds. *Educational Researcher*, 27 (4), pp.12 – 21.

Lemke, J. L. (1990). *Talking Science: Language, Learning and Values*. Abex: Norwood, New Jersey.

Marshall, S. & Gilmour M. (1991). Problematical words and concepts in physics education: a study of Papua New Guinean students' comprehension of non-technical words used in science. *Physics Education*. 25 (6), pp. 330-337.

Marshall, S., Gilmour M. & Lewis, D. (1991). Words that matter in science and technology: a study of Papua New Guinean students' comprehension of non-technical words used in science and technology. *Research in Science and Technological Education.* 9 (1), pp. 5-16.

Mason, M. & Mason, B. (1997). *Breakthrough to Learning: Linguistics in the service of Mainstream Education*. London: Trentham Books Limited.

Miller, G (1999). On Knowing a Word. *Annual review of Psychology*, 50, pp. 1 – 19.

Mortimer, E. F. and Scott, P. (2003). *Meaning Making in Secondary Science Classrooms*. Maidenhead and Philadelphia: Open University Press.

Murphy, G. (2002). *The Big Book of Concepts*. Cambridge Massachusetts: MIT Press.

Ogborn, J., Kress, G., Martins, I. & McGillicuddy, K. (1996). *Explaining Science in the Classroom.* Buckingham and Philadelphia: Open University Press.

Ogot, B. A. (2003). *An Autobiography: My Footprints in the Sands of Time*. Kisumu, Kenya and Victoria, Canada: Anyange Press and Trafford Publishers.

Oyoo, S. O. (2000). *Understanding of some Non-Technical Words in Science and suggestions for the effective use of Language in Science Classrooms*. Unpublished M.Ed. (Science Education) dissertation. School of Education: University of Leeds, UK.

Oyoo, S. O. (2004). *Effective teaching of science: the impact of physics teachers classroom language*. PhD thesis, Faculty of Education, Monash University, Clayton Campus, Victoria, Australia.

Oyoo, S. O. (2006). Science teachers' awareness of the impact of their classroom language. In P. L. Jeffery, Proceedings of the International Education Research Conference of The Australian Association for Research in Education, University of Western Sydney, Parramatta; CD Version ISSN 1324-9320; WWW Version ISSN 1324-9339, April 2006.

Oyoo, S. O. (2008). Going Round the Foreign Language Problem in African Science Classrooms; In A. Garuba and L. Irwin (Eds) *Teaching and Education for Teaching in an era of Globalisation in Developing Countries: Essays in Honour of Jophus Anamuah-Mensah* (Chapter Eight/ pp. 103-124); SACOST University of Education Winneba, Ghana. ISBN 9988-638-63-9

Oyoo, S. O. (2009). Beyond General Proficiency in Language of Instruction: Towards The Appropriate Perspective on Language for Effective Learning in African Science Classrooms. In M. Shafer and C. MacNamara (Eds.), *Refereed Proceedings of the 17th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE 2009)*, 19 – 22 January 2009, Rhodes University, Republic of South Africa, pp. 197 – 212. Volume I (Long Papers) Book Version ISBN 978-92-990043-6-4; CD Version ISBN # 978-92-990043-6-4

Peacock, A. (1995). An agenda for research on text material in primary science for second language learners of English in developing countries. *Journal of Multilingual Development*, 16 (5), pp. 389 – 401.

Peacock, A., Cleghorn, A. & Mikkilla, M. (2002). Multiple perspectives on the teacher-learner-text relationship in primary school science. *Curriculum and Teaching*, 17, pp. 54 – 71.

Pickersgill, S. & Lock, R. (1991). Student understanding of selected non-technical words in science. *Research in Science and Technological Education*, 9, (1) pp. 71-79.

Prah, K. K. (2003). Going native: Language of instruction for education, development and African emancipation, In B. Brock-Utne, Z. Desai and M. Qorro (eds) (2003), *Language of instruction in Tanzania and South Africa (LOITASA)*, pp.14 – 34. Dar es Salaam: E & D Limited.

Prophet, B. & Towse, P. (1999). Pupils' understanding of some non-technical words in science.

*School Science Review,* 81 (295), pp.79-86.

Rodrigues, S. & Thompson, I. (2001). Cohesion in science lesson discourse: clarity, relevance and sufficient information. *International Journal of science Education,* 23 (9), pp. 929-940.

Rollnick, M. (1998). The Influence of Language on Second Language Teaching and Learning of Science. In W. W. Cobern (Ed), *Socio-Cultural Perspectives on Science Education: An International Dialogue*, pp.121-138. Dordrecht: Kluwer Academic Publishers.

Rollnick, M. (2000). Current Issues and Perspectives on Second Language Learning of Science. *Studies in Science Education*, 35, pp. 93-122.

Rolstad, K. (2005). Rethinking Academic Language in Second Language Instruction. In J. Cohen, K. T. McAlister, K. Rolstad & J. MacZwan (eds), *ISB4: Proceedings of the 4th International Symposium on Bilingualism*. Somerville, MA: Cascadilla Press. Available at www.cascadilla.com/isb4.html

Roy-Campbell, Z. M. and Qorro, M. A. S. (1997). *Language crisis in Tanzania: the myth of English versus education*. Dar es Salaam: Mkuki na Nyota Publishers Limited.

Scott, P. H. (1998). Teacher Talk and Meaning Making in Science Classrooms: a Vygotskian Analysis and Review. *Studies in Science Education*, 32, p. 45-80.

Sutton, C. (1992). *Words, science and learning*. Milton Keynes: Open University Press.

United Nations Educational, Scientific and Cultural Organization (2007). *Making a difference: effective practices in literacy in Africa*. Hamburg: UNESCO Institute for lifelong Learning.

Vygotsky, L. (1986). *Thought and Language* newly revised and edited by Alex Kozulin. Cambridge MA, London: The MIT Press.

Wellington, J. & Osborne, J. (2001). *Language and Literacy in Science Education.* Buckingham, Philadelphia: Open University Press.

Wellington, J. (1994). Language in Science Education. In J. Wellington (Ed) *Secondary Science: Contemporary Issues and Practical Approaches*. London, New York: Routledge.

Wilson, J. (1999). Using Words about Thinking: Content Analyses of Chemistry Teachers' Classroom Talk. *International Journal of Science Education,* 21 (10): 1067 - 1084.

Yandell, J. (2003). Thoughtless Language, or The Death of Child-centred Education. *Changing English*, Vol. 10 (1), pp. 5 – 12.

Yore, L. D. &Treagust, D. F. (2006). Current Realities and future Possibilities: Language and science literacy – empowering research and informing instruction. *International Journal of Science Education*, 28 (2-3) February 2006, pp. 291 – 314.

Yore, L., Bisanz, G. L. & Hand, B. M. (2003). Examining the literacy component of science literacy: 25 years of language arts and science research. *International Journal of Science Education,* 25 (6), pp. 689 – 727.