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Language in Science Classrooms: An Analysis of Physics Teachers' Use of and Beliefs About Language

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Abstract The world over, secondary school science is viewed mainly as a practical subject. This may be one reason why effectiveness of teaching approaches in science education has often been judged on the kinds of practical activity with which teachers and students engage. In addition to practical work, language—often written (as in science texts) or oral (as in the form of teacher and student talk)—is unavoidable in effective teaching and learning of science. Generally however, the role of (instructional) language in quality of learning of school science has remained out of focus in science education research. This has been in spite of findings in empirical research on difficulties science students encounter with words of the instructional language used in science. The findings have suggested that use of (instructional) language in science texts and classrooms can be a major influence on the level of students' understandings and retention of science concepts. This article reports and discusses findings in an investigation of physics teachers' approaches to use of and their beliefs about classroom instructional language. Direct classroom observations of, interviews with, as well as content analyses of the participant teachers' verbatim classroom talk, were used as the methods of data collection. Evidence is presented of participant physics teachers' lack of explicit awareness of the difficulty, nature, and functional value of different categories of words in the instructional language. In conclusion, the implications of this lack of explicit awareness on the general education (initial and in-service) of school physics teachers are considered.

Keywords Physics teaching · Language of instruction · Initial preparation of physics teachers · Continuing professional development of physics teachers

Introduction and Overview

This article reports and discusses findings in an investigation of physics teachers' approaches to use of and their beliefs about classroom instructional language in Kenya

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where, in common with many other countries the world over, secondary school science is viewed mainly as a practical subject. This view of secondary school science may be the main reason why effectiveness of teaching approaches in science education is often judged on the kinds of activity—practical or not—with which teachers and students engage (Leach and Scott 2003; Mortimer and Scott 2000) during teaching and learning science. In Kenya, the importance of practical work in teaching and learning science is evident in the assessment policy; the Kenya National Examinations Council (KNEC) awards A and B grades only to those candidates who have also done well in the practical component of the Kenya Certificate of Secondary Education (KCSE) national (pre-university) examinations in biology, chemistry and physics (Republic of Kenya 1999; Yussuffu 1990). In spite of the prominence given to practical work in the Kenyan system of education, use of language, often written (as in science texts) or oral (in the form of teacher and student talk), cannot be avoided in effective teaching of science. This is evident in the following description of the teacher's work during effective teaching of science,

> …teachers convey the ideas of science by trying their best to explain the *concepts* and *operations* clearly …make use of metaphors …demonstrations and practical work to flesh out abstractions …utilise projects and discussions for involving students in the subject matter. (Matthews 1998, p. 9)

The importance of language as talk has been recognised in all activities associated with effective teaching and learning of science including in practical work (Högström et al. 2010; Sutton 1998). This is evident in the assertion that "meaningful practical work, whether by scientists or by children, is always embedded in conversation,—a discussion of ideas that makes it necessary to check those ideas against experience" (Sutton 1998, p. 174). According to Högström et al. (2010), "such interactions could result in consensus and common understandings of issues brought about during labwork and thereby promote students' learning of science" (p. 507). The foregoing assertions make it more apparent that teachers' and students' talk around the learning activities during practical work are of importance for learning (Driver et al. 1994; Leach and Scott 2003; Mortimer and Scott 2000; Ogborn et al. 1996; Sutton 1998). Hence, it can now be recognised that teaching and learning science occurs extensively in the medium of language (Wellington 1994; Henderson and Wellington 1998; Wilson 1999; Bleicher et al. 2003). While the role of written language or writing in science teaching and learning has been the subject of many studies in science education research (Hodson 2009), the manner of use of instructional language during teaching by the science teacher as a factor in quality of learning of school science is still a rare focus (Brock-Utne and Holmarsdottir 2003; Fensham 2004; Oyoo 2004). In the study reported in this article, the manner of use of (instructional) language in classrooms by teachers was an important object of study on the basis of three very important issues.

The Manner of Teacher Use of (Instructional) Language in Classrooms: Why the focus?

The first issue and the reason why the focus in this article is on the teachers' use of instructional language during teaching is based on the now well recognized role of language in concept formation and development (Vygotsky 1978). The second issue has been the justifiable need for intervention by a knowledgeable other (teacher) in the learning of school science (Driver 1989; Hodson and Hodson 1998; Tharp and Gallimore 1988). The science teacher is the foremost resource in students' effective learning of science, based on the convincing argument that learners need to be guided as they discover the ideas of school science (Driver 1989; Hodson 1999; Mortimer and Scott 2003). Support for the argument centres on notions that "…learning science … involves … the individual … being initiated into 'ways of seeing' …such 'ways of seeing' cannot be 'discovered' by the learner …" (Driver 1989, p. 482). The purpose of teacher intervention in learning science is therefore to help shape students' views to fit criteria of what counts as scientific knowledge as known within the scientific community. Language is a necessary tool in the intervention process, especially how it is used by the knowledgeable others (teachers) in providing the guidance (Scott 1998), hence the third issue. The third issue derives from the work on classroom observation by Ned Flanders (1970); a finding in this early work has remained about the same in several other studies across a wide range of teachers and across countries (Barnes et al. 1986; Barnes and Todd 1995; Bleicher et al. 2003; Gibbons 1998; Edwards and Mercer 1987). It has been the observation that the greater percentage of talk in many classrooms is talk by the teacher. Ned Flanders showed that on average, two thirds of each lesson comprises of talk, and two thirds of this talk is teacher talk; Edwards and Mercer (1987) have restated this as the two thirds' rule of classroom interaction: "for about two thirds of the time someone is talking; (b) about two thirds of this talk is the teacher's; (c) about two thirds of the teacher's talk consists of lecturing or asking questions" (p. 25). While the actual percentage of teachers' classroom talk in any classroom including those of science may be expected to be dictated by the content to be learnt or teaching approach, this observation has marked out the prominence of teachers' classroom talk/language in teaching and learning science.

The three issues have not only highlighted the reasons for the focus on the teacher's instructional language in this article, but also of its vital importance to student learning of scientific concepts. Teacher's instructional language may therefore be rated on equal footing to practical work in terms of enabling successful learning of the science concepts. All practical work undertaken in the teaching and learning processes necessarily needs to be appropriate to the learning demands. Teachers' instructional language similarly needs to be appropriate to the learning demands, for example, the context and the learners' linguistic levels (Oyoo 2009); this is especially argued on the basis of the role of language in concept formation and development. While the learner's proficiency in any instructional language is a necessary first step for all learning (Oyoo 2007), an overview of the nature and general difficulty of the instructional language as used by science teachers in classrooms is of central relevance to this study.

The Components and Nature of Science Teachers' Language

The instructional language (English) used in a teacher's classroom has two parts: technical component and non-technical component. ***The technical component*** is made up of technical words or terminologies specific to a science subject; these may also be referred to as technical terms, scientific terms/terminology, or simply science terms. Technical words "…include such things as physical concepts (mass, force…) names of chemical elements, minerals, plants, organs, processes, apparatus…"(Gardner 1972, p. 7). The technical/ science words are everyday words deliberately used (Miller 1999) *as* science words and have new (scientific) meanings in addition to their every day meanings (Sutton 1992; Wellington 1994). While this is one explanation of the origin of polysemy of these science words, the new and different meanings everyday words acquire when used *as* science words, and/or when they become science words resemble words in a new, different or "foreign language" (Vygotsky 1962, p. 109), though with fixed meanings. Regardless of the base language, the meanings of these words must be known in the international science community circles. The plural nature of science words has also been argued; this has been to include science words as representations of the science culture (subculture) distinct from the everyday (dominant) one and as a distinct language, in addition to representing 'science concepts' (Murphy 2002). Any science word therefore has "…a triple identity i.e., conceptual, cultural and linguistic" (Oyoo 2007, p. 232).

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 may be recognisable to be the same as the language in which a science text book is written. Examples of non-technical words are italicised in the following:

> Gas molecules display *random* motion; we may *predict* their behaviour from *theoretical* considerations: the actual volume of the molecules may be *neglected*. (Gardner 1972, 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. This is especially on the assumption that the meaning of the (technical) term 'molecule' is known to the learners. In science education research studies relevant to this article (see Gardner 1971, 1972; Cassels and Johnstone 1980, 1985; Pickersgill and Lock 1991; Marshall et al. 1991; Farell and Ventura 1998; Oyoo 2000, 2004; Prophet and Towse 1999), it is words like these, that have been interchangeably referred to as 'non-technical words in the science context' or everyday words used in the science context. This reference is maintained in this article to distinguish them from two other groups of everyday words considered here as distinct categories of non-technical words: these are the metarepresentational terms (Wilson 1999) and logical connectives (Gardner 1977a, b). 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,*[1] 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 in chemistry more 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 et al. 1969, 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.

[1] The *non-technical words in the science context* is given special mention although they are non-technical words like metarepresentational words and logical connectives because they have been referred to as such in the particular research studies (mentioned in text) which the study this article reports on aimed to extend. In these studies, logical connectives have similarly been referred to as logical connectives and metarepresentational words as metarepresentational terms. All categories are however non-technical words.

The *metarepresentational terms* specifically, refer to the non-technical words that signify *thinking*; these include metalinguistic and metacognitive words as defined next. 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)" (Wilson 1999, p. 1069). Evidently, metarepresentational terms (metalinguistic and metacognitive words) 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 during questioning in talk-led classrooms or 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 (1988, 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 examination questions so as to accordingly design the correct responses (Bulman 1988). Rodrigues and Thompson (2001) have also argued that students' understanding of the meanings of these words may enhance their classroom participation.

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" (Gardner 1977a, p. v). Examples include *conversely, if, moreover, because, therefore, in order to, consequently, by means of*, and *since*. The importance or functional value of logical connectives as may be evident from these examples, is that they are words that "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 …" (Fensham 2004, 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. The general difficulty of these words is discussed in the next section.

General Difficulty of Words in the Total Language of the Science Teacher

As so far established, the total language of the science teacher consists of technical terms, i.e. science words/science content as well as non-technical terms, i.e. *non-technical words in the science context, metarepresentational terms* and *logical connectives*. The general difficulty of science words, hence school science/science content, is a well-known worldwide phenomenon that varies in extent depending on the specific circumstances in different countries (George 1999). Yet to be as appreciated widely is the difficulty of words in the non-technical component of the total teachers' language, apart from any learning difficulties consequent on students' levels of proficiency in the instructional language. As suggested by several cross-national studies, students encounter difficulties with all the categories of words in the entire non-technical component of the science teacher's classroom language in addition to the difficulty with science words. A review of these studies with the distinctive focus on the perceived influence of students' proficiency in English (the instructional language) on levels of students' understandings of the non-technical words has revealed that,

> …students encounter difficulties with all categories of everyday [non-technical] words common in science teachers' classroom language irrespective of whether they learn science using their first language or not (linguistic circumstances), or whether

> they are females or males (their gender). The types of students' difficulties have also been irrespective of individual cultural backgrounds.
> Oyoo (2004, pp. 70–71)

This general outcome, especially the fact that difficulties with everyday words of the English language when used in the science context are encountered by all learners "irrespective of whether they learn science using their first language or not" (see quote immediately above) is a strong support for the empirically based assertion that "every day words when used *in* a science context cease to be mere English words" (Marshall and Gilmour 1991, p. 334). Since the general difficulty of everyday words when used in the science context is in addition to that of science words/concepts, all categories of words in the language of the science teacher are therefore generally difficult; the difficulty of words in the instructional language therefore presents the linguistic face of the difficulty of school science. The review outcome is therefore a strong suggestion for a rethink of considerations of students' proficiency in an instructional language as a factor in the difficulty of school science (Oyoo 2007). Evidence may be available of the general neglect or ignorance of the fact that science, via the different meanings of everyday words when used *as* science words and/or *in* the science context, constitutes a distinct language, a language in which only those with science backgrounds may have contextual/relevant proficiency.

Rationale, Purpose, and Design of the Study

The apparent neglect of the manner of teacher use of language during teaching was the major concern in the larger exploratory study from which this article has been drawn. In the larger study, the following was the umbrella question: *How is the manner of use of language of instruction in the classroom by the science teachers a source of the difficulties students encounter in learning and retention of scientific concepts?* The nature and general difficulty of words used in science teachers' classroom language (as so far reviewed in this article) suggested a need to focus on teachers' classroom language (teacher talk) as an important factor in effective teaching and learning of science. The focus on words in teacher talk was based on the prominence of words in a language (of science) as has been argued in the words,

> All of what we customarily call "knowledge" is language. Which means that the key to understanding a "subject" is to understand its language…what we call a subject is its language. A "discipline" is a way of knowing, and whatever is known is inseparable from the symbols (mostly *words*) in which the knowing is codified.
> [Postman& Weingartner (1971, p. 102) in Hodson (2009, p. 242); italic, my stress]

The particular argument that "whatever is known is inseparable from the …words in which the knowing is codified" (Hodson 2009, p.242) is the cornerstone or rationale within which the discussions on the issue of language in this article[2] centres on the words used in learning and teaching science. This particular focus on language ascribes to the pragmatic perspective on language (Wickman and Östman 2002) where, "the meaning of a word is its use and function in a specific activity" (Gyllenpalm et al. 2010, p. 1155). This suggests a need for shared thinking towards a common understanding of the meanings of words in all contexts of use even where the language of interaction or instruction in classroom

[2] This is unlike the perspective in Halliday and Martin (1993) where the focus is on written language.

circumstances is in a student's first language. While more on methodological issues about the larger exploratory study is presented later, this article has focused on two prime concerns in the larger exploratory study.

- Whether teachers of physics/science are aware that differences in word meanings in everyday parlance vis-a-vis in the science context are a source of the difficulties in learning science to their students? If so, then how do the teachers respond or what do they do about it?
- Secondly, retention of what is taught depends on how much shared thinking goes on during learning. Why and what approaches do teachers prefer in emphasizing shared thinking (explicitly or implicitly) during teaching?

The focus in this article is therefore on the teacher's role with regard to students' understanding of the meanings of everyday words when used in the science context, based on 1) the possibility of polysemy of the everyday words when used in the science context, 2) disparity between home and school language, as well as 3) levels of student proficiency in the language of instruction. As so far suggested by the review outcomes and discussions on the nature and general difficulty of the teacher's classroom language, the ideal approach to the use of language would be for the teacher to take special attention to provide meanings of words within the context of use, while at the same time being aware of possible limitations in students' development in the language of instruction. As may also be apparent from the reviews and discussions so far in this article is the fact that proficiency in the language of instruction may be only part of the story in students' relative ease in accessing the meanings of words in the characteristic classroom language of the science teacher.

The teacher's use of instructional (English) language during teaching in this study was therefore not on the variety of the instructional language (English) used or the specifics of grammar (Cleghorn et al. 1989) but on the explanations of meanings of words/concepts in the context as used during teaching. The view of 'context' adopted in this article is more than just the physical and learning environment. Context is taken to include cognitive representations that are altered through the reinterpretation of meaning (Cazden 1988; Rodrigues and Thompson 2001), including the meaning(s) of a word vis-a-vis its meaning (s) in everyday language. The perspective on language in this article is therefore a pragmatic one: "the meaning of a word is its use and function in a specific activity" (Gyllenpalm et al. 2010, p. 1155). The focus on the level and the manner of use of language by the teacher in explaining the meanings of the words in the context of use, in addition to the leading role of the teacher as the knowledgeable other (as so far discussed), is appropriate to the argument that "the content of instruction plays a primary role in determining gains in student achievement" (Porter 2002, p. 3). Further, this focus was considered in the light of the possible profound impact of teachers and their approaches on student learning.

> Teachers, as they interact with students, are the ultimate arbiters of what is taught (and how). They make decisions about how much time to allocate to a particular school subject, what topics to cover, when and in what order, to what standards of achievement, and to which students. Collectively, these decisions and their implementation define the content of instruction. (Schwille et al. 1983, p. 3)

This quote (immediately above) is recognised to also describe the crucial role of the teacher as the knowledgeable other in learning science. The decisions and their implementation define the content of instruction including the role the teacher could be expected to play with regard to students' understandings of all words used in the science context. This view makes it apparent that it is the teacher who ultimately impacts directly on student learning of science concepts irrespective of the number of other factors/variables that impact on student learning (Tytler 2003). It also may be considered a strong suggestion that a science teacher's approach to language use in classrooms could be a source of students' difficulties with all words used in the science context. Although the teachers' use of language in classrooms may be a potential source of the students' difficulties with the non-technical words and/or with general learning, the extent of this might often be dependent on many factors, some of which will be beyond the teachers' control.

Determinants of Effectiveness of a Teacher's Classroom Performance

While science teachers' classroom practice is often based on contemporary teaching approaches as learnt during their initial education as teachers, in addition, a teacher's actual classroom approaches may in many instances be influenced by a combination of experiences. Porter, in reference to his earlier work with colleagues (see Porter et al. 1998), has asserted that "…messages can come from a teacher's own experience as a student, and as a teacher in training (i.e. through pre-service teacher education), and as a teacher" (Porter 2002, p. 10). This assertion implicitly suggests that initial teacher education does not provide for all the pedagogical knowledge a teacher may have; some may have been derived from outside the teacher education circles including during the teachers' schooling, e.g. influences of their former teachers. Hence support is given to the particular argument that pre-service or initial teacher education does not offer the teacher the 'all' towards efficacious classroom practice (Asoko 2000). In actual classroom practice however, the fact that teachers' decisions on teaching are generally influenced by their beliefs and experience has been argued.

> The beliefs of a teacher are grounded in experience. Those beliefs that have proved to be viable, in the sense that they have enabled the teacher to meet his/her goals, are used as a guide for actions and those that are not viable in particular contexts are not used as referents for action. (Tobin and McRobbie 1999, p. 215)

With regard to teacher's experience, it may follow that generally, the approaches used by teachers may be based mainly on their perceptions and/or beliefs about how students of particular levels of ability (linguistic and general academic) learn, yet these may not be favourable to all the students in any one classroom. Teacher experience as a factor may also be considered on the novice to experienced teacher continuum, where the novice teachers may be judged inept at handling lessons including ability to facilitate students' learning of the meanings of everyday words when used in the science context. Yet the lesser impact of novice teachers may well be because they need time to adjust to the "teaching demands of teaching[3]" (Asoko 2000, p. 90), including mastery of school level content. To help situate the study reported in this article, details of the context of the study and the participants are now presented.

[3] Teaching demands of teaching may be taken to refer to activities teachers often have to engage in to make their teaching successful, like making lesson plans, adjusting to certain categories of students and generally what it means to be a teacher.

Study Population: Kenyan Schools, Students and Physics Teachers

The Secondary Schools in Kenya

The secondary schools are broadly classified as either public (government supported[4]) or private. The public secondary schools are the majority and these are further categorised as National, Provincial or District schools. While all National schools are single sex and boarding, the rest are either single sex or co-educational, boarding or day schools. The number of public secondary schools across the country is just over 4500, with another 300 being private (Bauer et al. 2002). The total enrolment in the secondary schools is about 700 000 students; girls comprise 47% of this (Njeru and Orodho 2003). The National schools have a long history. Some are over 100 years old and are the better endowed in terms of well developed infrastructure and equipment for all school subjects, most notably the sciences (Bali et al. 1984). The Provincial schools that were constructed in the 1960s and 1970s are equally well endowed and are on an equal footing with the National schools in many aspects—these are the centres of academic excellence at secondary school level in the eight regions or provinces[5] in the country. While a few newer Provincial schools, depending on their sponsoring bodies, have very good facilities in place, a large number of these are called Provincial schools only on the basis of their large student populations. Comparatively, most of the District schools are not as well endowed, particularly with regard to general infrastructure and equipment necessary for the usual conduct of science education, including carrying out of regular practical work. The number and distribution of the Provincial and District schools has been influenced by many issues: political, economic, climatic, and local wealth. The latter is the result of the government's policy of cost sharing in education, a policy that "…has increased inequalities, as regions with 'nothing to share' have been unable to contribute to educational development" (Republic of Kenya 1999, p. 258).

The Students

The primary school pupils usually progress to the secondary level upon satisfactory attainments on the end of the primary cycle examination, the Kenya Certificate of Primary Education (KCPE). Although the primary pupils select their preferred secondary schools during registration for the KCPE, over the years,

> All … always aim for a place in a National or at least one of the older, better established, provincial schools …mainly because these schools offer substantially better chances for continuation to the next level. Unlike in the small District schools, the schools' facilities allow for a wider choice of science-based and practical subjects which broaden the range of possible career choices at the end of secondary school. Bali et al. (1984), p. 14)

It is the number of places in these secondary schools that usually determines the KCPE cut-off mark and the number of students selected to join Form One (Year 9). While the demand for secondary schooling within the more developed and richer districts usually results in higher cut-off points generally, the cut-off points may vary by gender because students compete separately for a non co-educational school level (Bali et al. 1984). This

[4] Government support is only in deployment and payment of teachers' salaries.
[5] The 26 National Schools are concentrated in Central, Nairobi, Nyanza and Rift Valley provinces but none in the remaining four provinces: Coast, Eastern, North Eastern and Western Provinces.

means that many students, even after attaining satisfactory levels in the KCPE never get places in the secondary schools. Selection into Form One is based on a quota system such that the best student(s) in a district would be selected at national level to join a National secondary school. Once the National schools have filled all their vacancies (only 4517), all the remaining students would compete for the vacancies in the Provincial schools in the provinces where they sat for the KCPE. The Provincial schools must fill 65% of the Form One vacancies with students from the districts where they are located, 30% are admitted based on quotas for each of the remaining districts within the province of location of the Provincial school and the remaining 5% are admitted from any part of the country. The remaining students would be selected by the District schools; in many cases the students selected by the District secondary schools would be those who sat for the KCPE in primary schools in their immediate neighbourhoods.

The quota system of selection ensures that the National schools and the majority of the Provincial secondary schools always get students with higher KCPE scores than the District schools. In spite of the method of selection into the secondary schools, all students at the public secondary schools in Kenya at Form One level are not just students. This claim is based on the reasonable assumption that all Form One students are those who have attained satisfactory levels in the skills of writing, arithmetic, creativity and communication skills of listening and self expression—skills necessary for a smooth transition to secondary education (Republic of Kenya 1999). This can be expected in light of the fact that the number who eventually join the secondary level are only a small fraction of the total population of those who sit the KCPE in any 1 year. The point is that, generally, even those in the District secondary schools are not poor students[6] and some could have scored only one mark lower than many in the National or Provincial schools. The general academic abilities of the students who were involved in the study were therefore deemed satisfactory.

Kenyan Physics Teachers and Their Preparation

The teachers in the public secondary schools are all employees of the government of Kenya through the Teachers Service Commission (TSC). There are two broad categories of secondary school teachers—the trained and the untrained. Science teachers among these come in four categories: Untrained University Graduate teachers (holding a BSc degree), S1/Diploma Certificate teachers, trained Diploma Technical teachers and Trained University Graduate teachers. Although the system of education has now changed from 7-4-2-3 to the current 8-4-4, most of these teachers passed through the former 7-4-2-3 (British) system of education before joining teacher education institutions. The proportion of 8-4-4 teachers among those in current workforce is still very small as the government has still not lifted the freeze on mass employment of teachers that has been in place since 1997. Pre-service education of secondary school teachers is carried out at two levels, the graduate teachers at the universities and the non-graduate teachers in the Diploma Teachers' colleges. In the 7-4-2-3 system, the Bachelor of Education degree training took 3 years, while the Diploma in Science Education training took 2 years. The duration of training for the precursor to Diploma in Science Education, the S1 grade, took 3 years (Meyer 1993). Graduates holding BA and BSc took 1 year for the post-graduate Diploma course in

[6] Some students who for economic reasons have to decline their places in the Provincial and even National schools join District day schools in the neighbourhood of their homes. This tendency in enrolment is common with many District schools across the country and it is such students who eventually opt for physics in spite of the relatively 'anti-science' environments typical in most District schools across the country.

education. Graduate teachers of the current 8-4-4 system are trained in 4 years for the Bachelor of Education Degree (B.Ed). Graduates holding BA and BSc still take 1 year for the post-graduate Diploma course in education while the Diploma in Science Education teachers are now trained in 3 years and Diploma Technical Teachers course takes a total of 15 months[7]—1 year and a term. While the current (8-4-4) crop of teachers with a Diploma in technical education certificate are strictly speaking not science teachers, those trained prior to 8-4-4 were and are still in secondary schools, teaching mainly physics and mathematics. Selection of teacher trainees for Diploma level is done by the Ministry of Education while recruitment of the graduate teachers is done by the Universities' Joint Admissions' Board (JAB). The mean grades attained in the preferred teaching subject combinations have often been the main determining factors for who is actually offered admission into the teacher education institutions in addition to the overall cut-off mean grade during each admission. The same admission bodies for the two categories of teachers have been able to influence the scope and nature of education these student teachers are offered before being released into the job market. As already mentioned, the Teachers Service Commission (TSC) of Kenya is the sole employer for the public schools. It is from this pool of teachers that selection of physics participants in the study was done.

Selection of Physics Teacher Participants

In Kenya, all secondary school physics teachers—non-graduate and graduate—are by training, able to teach across the secondary school, i.e. from Form One (Year 9) to Four (Year 12) in Kenya's 8-4-4 system of education. All teachers teach the same content from a common syllabus/curriculum to all students for the same university entrance examination—the KCSE. The level of training (graduate or non-graduate) was therefore not a factor in the selection of the physics teachers who participated in the study. Similarly, post-qualification teaching experience was not a major factor, based on the determinants of teachers' classroom effectiveness as so far discussed, including: 1) the diverse factors (individual and student/school dependent) of teachers' classroom performance, 2) that the current physics teachers in Kenya were educated through different systems of education, 3) that initial teacher education never produces a teacher as a finished product (Asoko 2000), and 4) that generally, teachers' conception of (physics) teaching approaches, including use of language in classrooms, may not have a single influencing source (Porter 2002). (Novice) teachers, especially those with less than a year in the teaching profession, were however excluded based on the probability that they still needed time to counter the challenges and stresses encountered during adjustment to teaching in schools (Wanzare 2007). What could not be overlooked in the selection of the physics teacher participants was that the teachers had to be those teaching at the level of school that was targeted for this study—Form Three (Year 11). The type of sampling procedure used with teachers was therefore 'purposive' with regard to class level taught. Nine physics teachers, from six public secondary schools (including National, Provincial and District) participated in the study; only two of these were females. The specific details of the participant teachers who throughout the study are referred to only as **T1**, **T2**…**T9**, for gender and cultural neutrality are as shown in Table 1. As evident in Table 1, the lengths of teaching service of these teachers ranged from two to 23 years. At the time of this study, six were serving heads of science or physics departments

[7] The shorter period is because the candidates are currently selected from those who have already taken a three year diploma course after KCSE in a technical subject, e.g. computers, basic engineering etc.

Table 1 Summary of details of the teacher participants

CODE	QUAL. (S)	TEACH. SUB.	YEARS OF SERV.	ADM. RESPONSI.
T1	B.Ed.	Physics/Mathematics	11	HOD Science/KNEC
T2	B.Ed.	Physics/Mathematics	5	HOD Physics
T3	B.Ed.	Physics/Chemistry	2	Class teacher
T4	B.Ed.	Physics/Mathematics	12	HOD Science/Physics/KNEC
T5	B.Ed.	Physics/Mathematics	22	HOD Science/KNEC
T6	Dip.Ed./B.Ed.	Physics/Chemistry	13	Class teacher/KNEC
T7	B.Ed.	Physics/Chemistry	5	Class teacher
T8	S1/Dip.Ed/B.Ed.	Physics/Chemistry	23	HOD Science/KNEC/Principal
T9	B.Ed.	Mathematics/Physics	9	HOD Mathematics and Science/KNEC

KEY: *Dip. Ed.* Diploma in Science Education; *B.Ed.* Bachelor of Education (Science); *HOD* Head of Department; *KNEC* Physics Examiner with the Kenya National Examinations Council (KNEC); *QUAL.* Teaching qualification; *TEACH. SUB.* Teaching subjects; *ADM. RESPONSI.* Administrative responsibilities; *YEARS OF SERV.* Years of service

in their respective schools. One of these teacher participants had even served as a school principal; the majority of them then were therefore very senior teachers.

The backgrounds and teaching circumstances of all the participant teachers varied depending on schooling and teacher education backgrounds, teaching experience and types of schools served at as well as gender of the students so far taught. Each teacher participant was therefore considered to represent an example of practice against their particular backgrounds. Although English is the second language to most students and their teachers, the language level of the physics teachers was deemed sufficient for teaching since they had used English language over a much longer period than their students in addition to having been tested in the language prior to their acceptance as trainee teachers.

The school student participants' levels in English language were considered satisfactory; these ranged from **A** (very good) to **C+**(average), based on the Kenya National Examinations Council grading system (see Meyer 1993; Yussuffu 1990) on KCPE when the students who were taught in the classrooms observed in the study took the examination. Why the study targeted physics teaching at secondary school level is now explained to provide for its contextual relevance.

Why Investigate Teachers' Language Use in the Teaching of School Physics?

Although there have been studies of teacher use of language during teaching in the context of the population the study reported in this article has drawn from, these (Abagi et al. 1988; Abdi-Kadir and Hardman 2007; Cleghorn 1992; Cleghorn et al. 1989) have so far focused on teaching of science in primary school classrooms. This study targeted teaching of secondary school physics in order to benefit the learning of physics in Kenyan schools in the long run, as now argued: In Kenyan secondary schools, physics has the image of the most difficult school subject, one that only high achievers have the courage to register for in national examinations (Oyoo 2008). Despite the generally higher academic ability of the students who register for physics, it remains the subject where the outcome has been consistently and persistently lowest compared to other science subjects, Biology and Chemistry (Oyoo 2008). Generally, therefore, it was considered that a teaching approach to enhance the students' understanding of concepts and outcome in this area would be a major bonus to the science curriculum in Kenya. As evident in the study's umbrella question and specific aims that are the focus in this article, this was a study aimed at strengthening the effective use of language of instruction during teaching by Kenyan science teachers generally but physics teachers in particular.

Sources of Data

In the larger exploratory study, there was parallel data collected from the students and their teachers. A word test, focus and in-depth interviews were the methods used to collect data from the student participants, while from the physics teachers, direct classroom observations and interviews were used. In both instances, all responses during the interviews with the students and the physics teachers as well as all teacher utterances during the classroom observations were audio-taped. An additional strategy used in the collection of more data, though unobtrusively, was via content analyses of verbatim transcripts of audio-taped teachers' interview responses and classroom talk utterances. The data collection instruments that were used with these included a written test on understanding of words to students; an outline of a student focus group interview schedule; a student in-depth interview schedule; classroom observation framework/schedule; and an outline of teacher interview schedule. This article focuses on the two aims so far stated and draws wholly from direct classroom observations of and interviews with the physics teacher participants, but supplemented by data from content analyses of transcriptions of audio taped teacher utterances in observed classrooms as well as during interviews with the participant teachers.

Direct Classroom Observations

The purpose of the direct classroom observations were to lead to a contextual description of each teacher's classroom activities including approaches to classroom talk and use of other semiotics during teaching. The same number of lessons was observed for each teacher involved in the research exercise in order to counter for observer bias as well as observer effect on the physics teachers (Wallen and Fraenkel 2001). During these direct classroom observations, teachers' classroom utterances were audio taped and field notes were taken simultaneously as a necessary strategy to overcome the major difficulty often encountered in classroom observations: the possibility that the observer/researcher might miss a lot of what goes on in a classroom, where several behaviours of interest could be occurring rapidly (Wallen and Fraenkel 2001). The following were the specific concerns during the observations:

- What approach to language do science teachers actually use?
- Is the communication patterning in the classroom largely one of one-way transmission from teacher to student, or do students have opportunities to engage in conversation with the teacher and with fellow students?
- Are terms/words used explicitly without explanations or provision of alternative meanings presented?
- Are the metacognitive and metalinguistic terms implicitly or explicitly made reference to?
- Does the teacher explain or provide the contextual meanings of non-technical words when used in the science context? If so, then is there a clear approach in doing this?

- In sharing the contextual meanings of non-technical words used during teaching, does the teacher explore the other possible meanings of these words? Any other approaches used?

Teacher Interviews

The aim of teacher interviews was to source data to help in understanding issues relevant to the stated aims of the study, but specific to the circumstances of each teacher, and in the context of each school involved in the study. It was anticipated that some individual issues would arise from the classroom observations; the individual teacher interviews were therefore conducted after the direct classroom observations. The investigation of individual issues was necessary to present highlights on the nature of attention taken to teaching and learning practices by the respective teachers as could have been influenced by their respective circumstances, including particular school or student categories. To establish the teachers' general awareness of students' language difficulties, a general question, based on the characteristics of Kenyan physics students as already presented in this article, was used with all the physics teachers during the interviews. The common form of the question that revolved around their awareness of the type and nature of the language difficulties of their physics students was: "Now considering your students and especially the fact that they are physics[8] students are you aware of any language difficulties they encounter while learning physics?" Other questions followed on from the respective individual teacher's responses to this question, though all were meant to source information regarding how teachers made their teaching effective. Although the actual interview questions per teacher depended on the opinions formed by the researcher (this author), during the classroom observations, the broad areas that (within the aims of the study) were especially investigated in the interviews (in addition to the specific concerns that guided the classroom observations) included:

- What teachers considered good practice in the use of language in the classrooms during teaching;
- How the teachers had changed their teaching approaches with regard to language use in classrooms with time and why;
- Whether there had been specific constraints encountered by the teachers in their classroom teaching, particularly with regard to the use of language;
- Awareness of functional value of non-technical words in the school physics register.

The use of classroom observations together with the interviews in this study was to counter the tendency of teachers, during interviews, to delve into what they thought was appropriate, even if it would not accurately depict their own practice as observed. This tendency is common when teachers think the "data would be used for high stakes teacher evaluation purposes" (Porter 2002, p. 8) and was anticipated by teacher participants in the study from which this article has been drawn. A common strategy in both direct classroom observations and teacher interviews was for the researcher in this study to display a great interest in and desire to know the reasons for the preferred teacher approaches. This was for the fact that, regardless of the performances of the teachers as directly observed, the teachers were expected to be more aware of the teaching circumstances in each of their

[8] As so far mentioned, physics students are often the more able academically in any school based on their academic history generally as well as the policies put in place by most school science departments regarding who is allowed to register for physics (Oyoo 2008, 2010a, b).

respective schools and to the particular groups of students who attended the observed lessons. It would have been unrealistic of me (author/researcher), to expect the teachers to have taught the way I (as a teacher educator and physics teacher of long standing in similar contexts), or any other physics teacher would have handled the observed lessons and topics.

Data Analysis

The general approach to analyses of data had to be qualitative in nature; this was dictated by the methods used to source data for the part of the study that is the focus in this article. While an interpretive approach was used in the analyses of the interview responses and the field notes (see Fontana and Frey 2003, p. 87), an additional strategy used in the analysis was content analysis (Krippendorff 2004) of the verbatim transcripts of teachers' classroom talk. Content analysis was to enable a decision on a teacher's preferred approach to language use during teaching. The whole process of analysis was guided by the specific concerns in the direct classroom observations and the broad areas investigated in the teacher interviews. The analyses were however in reference to the two prime concerns/aims as so far mentioned. Content analysis, apart from interpreting meanings of non-technical words mentioned only implicitly, in some cases, involved literal picking and counting of the words used explicitly. This article is therefore a synthesis as well as a summary of the findings in the observations and interviews with the nine physics teachers who participated in the study.

Findings and Discussion

General Approach to Use of Language in Classrooms

The participant teachers had not been restricted to particular topics to teach since their participation was to be within their circumstances. The topics on which they were observed therefore varied, but were all from the Year 11 physics syllabus. The topics on which teachers were directly observed included: Quantity of heat, Waves, Particulate nature of matter, Electricity and Geometrical optics (curved mirrors). During the lessons, there were instances where participant teachers made explicit and implicit references to the words in their utterances, and apart from the technical terms, the everyday words special to the register of school physics in the topics covered were used. In all of the lessons observed, the teachers did most of the talking (Flanders 1970) and the students in most instances, talked only when they were expected to respond to teachers' questions. The mode of communication was therefore generally one-way from teacher to students. This was in the observation that most of the participant teachers generally controlled the talk during the lessons. How they did this included:

- Selecting who to talk among students whose hands would be raised up to answer a question;
- Students not being expected to verbalise any concerns but to instead raise up the left hand for the teacher to know when there is a difficulty;
- Teachers refusing to give answers to questions asked;
- Teachers rushing through the lessons hence giving no time for any students' questions;
- Teachers deciding who to ask a question irrespective of whether a student had his/her hand raised up.

This was in addition to teachers deliberately ignoring students' requests to explain meanings of certain words in the context as used during the lessons observed. This style of communication could be taken as a reflection of the participant teachers' preferred general teaching approach perhaps influenced by their teaching circumstances and demands, as well as their conceptions of the nature of and teaching of physics. More illustrations of such teacher classroom use of language are presented within the discussions in the next paragraphs.

Explanations of Meanings of Non-technical Words Used in the Science Context

In instances where the teachers provided the meanings of the words in the context of use, different approaches to explaining the meanings of certain non-technical words to the students were used. Salient among these included being precise with word meanings or avoidance of ambiguity in word use, teachers using simple language in the classrooms, and teachers announcing at the end of a lesson, difficult words expected in the lessons to follow so that students could look for their meanings in advance. One teacher (**T8**) who happened to be the most experienced of the nine teachers who participated in the study stood out in clear favour of making word meanings accessible by using examples from the students' immediate environment, including examples from the students' dominant local culture.

T8: Now have you walked around and seen these stones which just by nature, they are formed in a certain manner that you would think somebody was using a ruler to cut them? Where have you seen them?
Students: Even here at the school gate
T8: Yes, but that one you can say somebody was cutting them. Where have you seen them? How many of you eat stones[9]?
Students: Ehhe!
T8: You find that embarrassing?
Students: No!
T8: What happens? (*She fished out a piece of the edible stone*) Just look at this, just look at this edge here; look at this line here, it comes out so straight. Those of you who eat stones (some laughter). *Ama nimewaingilia niache*[10]?
Students: *Hapana*[11]*!*
T8: If you hit those stones then they don't just break like any other stone. Such stones split along straight lines. That tendency of crystals of splitting along straight lines leaving very smooth surfaces is called crystal cleavage. You 'cleave' along such lines …

The different approaches to use of language during teaching seemed to derive from different motivations. As evident in the individual analyses, these, in many cases seemed to be constrained by requirements of the assessment of content learnt. Teachers clearly stressed the meanings of certain words only as they gave tips to the students on how to respond should they meet the concepts/words in the examinations. For example, one participant teacher, in stressing the importance of the word 'specific', cautioned that, "the

[9] It is common for mainly pregnant women in the context of the study, to imbibe a category of porous stone (known locally as *odowa)* taken to be rich in iron.
[10] *Ama nimewaingilia niache* is Kiswahili for the question: "Could it be that I am being unfair to those of you who eat stones and should stop making such references?"
[11] *Hapana* is Kiswahili for "Not at all!"- Students responded in Kiswahili (the National language) since this is allowed but not use of their indigenous languages while at school.

moment you see the word 'specific', then we are talking about a unit mass." The observed participant teachers' tendency to explain the meanings of words used apparently depended on length of teaching experience, since those new to the profession explained the least. The teachers, who were newer to the profession (fewer years of service) still tended to operate in very abstract terms. For example

T3: … Now when an external wire connected between the copper and the zinc plate transfers electrons from the zinc plate to the copper plate, when that will happen, then 'conventional' current flows from the positive to the negative. Are you getting what I am saying?
T3: Today I want us to begin on a new topic and that one is 'Spherical or Curved Mirrors'. Now we have two types of spherical or curved mirror. One of them is a concave mirror, which we also refer to as converging mirror; the other type is the convex mirror, which is also called the diverging mirror. There are some terminologies associated with these mirrors before we can discuss how they form images…
T7: … So when we talk about plane polarization of waves, it can only occur when we are dealing with transverse waves because at this point we can have waves moving in different angles but in longitudinal waves, there is no angle between the particles and the longitudinal wave. So we cannot plane polarize a longitudinal wave because there is only one plane for the waves which is parallel to the direction of motion of the particles.
So where is this applied? Where do we apply polarization? So when we talk about polarization, where on earth do we use it? A situation where we are using only waves in one plane?
(*No answer from the students*)
T7: Yeah, this is so abstract ehh?
(*Giggles from the students*)

As evident in the excerpts immediately above, the teacher asked one question four times in quick succession (Flanders 1970) and got no answer from the students at all before giving up with the comment that the topic was "so abstract" (**T7**). He then answered the question himself (in the extract immediately below), and in the process used 'intensity', a word which he again did not attempt to explain.

T7: Hmm, we use it in glasses [spectacles]. Some of the glasses are dark and so on. But some of the glasses we use are made in such a way that they polarize light rays falling on them so that they reduce the *intensity* of light by allowing only light of one, *strength,* to pass through … [Pointing at a student in glasses] I wonder whether yours are plane polarized.

The context of use of the word 'strength' also could have been explained, although by referring to a student's spectacles, **T7** did attempt to provide an example of where polarization was useful in the everyday life of the students. As evident in the foregoing, the teachers' general approaches did not include moulding the content of the lesson as also presented in the physics course book to make it more understandable to their students—they in effect taught textbook physics. Compared to how teacher participants who had more years of service after qualification, this observation made it possible to argue that the relative ease with which the teachers gave explanations of any words they used in their teaching (i.e. the amount and quality of explanations), could have been dependent on their relative mastery of the subject matter content in the school physics curriculum. The teachers with fewer years of teaching experience (newer to the profession) in addition displayed impatience and uncoordinated presentation of the concepts during their lessons, apparently in attempts to get through all work planned for the lessons observed. This was observed in teacher **T9** for example, when he 'jumped' to a new item of the lesson, instead of giving more attention to a student who had asked for a clarification.

> **Student**: Is there a difference between the velocity and the speed of a wave?
> **T9**: The difference is that when we talk about a velocity, we are considering the magnitude and the direction but when we talk about speed, then we are talking about only the distance, the magnitude only but not the direction. So speed is a scalar quantity.
> **Student**: What about velocity?
> **T9**: Velocity is a vector quantity where two quantities are considered, magnitude and direction. (*Then without a pause, this teacher started on the next item of the lesson*) Types of waves: we have two types; the first one is transverse waves. Suppose you have a string and you shake one end of it up and down. What will happen?

This approach could be taken to have been unhelpful to students' understanding of concepts taught including non-technical words used during teaching. The rather too abstract approach by the teachers who had taught for fewer years could be interpreted in the context of the following submission by one participant teacher.

> Actually during training, we cover physics … at very high levels and therefore we use harder and very abstract words… So when you come back to do school physics, things are very simple then you think everybody is seeing it that way. (**T1**)

In this line of argument, it seemed logical to suggest that mastery of school level content including an appreciation of the difficulty of some commonly used words, apart from the participant teachers' general knowledge of physics, may have also depended on the years of teaching experience. This seemed apparent from the following response recorded from one such teacher:

> … .Earlier on there *was a problem with my language*. Either I was talking too fast or I was assuming that they know and this was at *the beginning of my teaching career.* Like I would assume the word meanings like … 'speed' is known, yet that was never the case. They are sometimes not obvious. So you should give them time to see whether this term you are using is really an obvious term. (**T7**, Italics my emphases)

How the Teachers Used Metarepresentational Terms during Teaching

In almost all cases where metarepresentational terms (metacognitive and metalinguistic words) were used explicitly by the participant teachers during the lessons observed, these were exclusively used when numerical questions (problems) were being solved; their meanings were generally only minimally explained by the teachers. Most participant teachers had observed during the interview that their students lacked understanding of word problems (questions) and were also often unable to interpret word questions. The following are examples of typical responses from some of the participant teachers:

> **T1**… It is true that they understand the concepts taught but the same students in their own construction cannot explain the same concepts. They cannot and especially if you give them a question that is specifically descriptive, like describing an

experiment, then you will realize that they do not have the right terminologies for certain things… due to the limitations in the understanding of the language.

T2 … actually they have a lot of problems in language, especially interpreting questions that are asked in English and also putting down the exact concept that is required of them when they are to write that down as an answer to a question.

T3 … These students … if you give them numerical questions, they see the numbers and they work them out but when you give the word questions, they don't. In fact they can't get it right because they have a problem with the spoken English and what I speak in class is usually very clear but they can't get it.

While lack of understanding of content may have been the main reason behind these difficulties, the non-explanation of the meanings of the metarepresentational terms as was the general approach by the participant teachers may have also been another factor.

Teachers' 'Beliefs' about the Value of Everyday Words Used in Their Classroom Language

The teachers who participated in the research generally seemed to view students' difficulties in learning physics to stem only from the difficulty of the subject and not from difficulties encountered with the contextual meanings of the non-technical words when used in the science context. This served as evidence of their general unawareness of the functional value of words in the non-technical component of their classroom language. Particular evidence could be in one participant teacher's response regarding the role of language in students' understanding of physics.

Researcher: Do you think that it [the students' language problems] can be classed as a factor in making the students not to like physics?

Participant teacher (T7): In physics there are not too many terms like in biology and chemistry, yet they find physics to be difficult. Can it be a major factor? I doubt whether it is a major factor because there are some subjects where terms are so new but still they like it.

While this participant teacher went ahead to argue that mathematics was the major factor in the difficulty of physics, his response as above revealed his lack of awareness of the place of non-technical words in students' enhanced understanding of the science concepts. The general approach was evidence that the participant teachers lacked explicit awareness of the role of these words in meaning making and concept formation discussed under the function of these words (in the review) or that some of these words embody science concepts and would hamper learning of the concepts if not explained in the context of use. Hence the failure by some of the participant teachers to provide the meanings of these words during teaching; to evidence this, a participant teacher even suggested that the words would become known by the students after being used repeatedly for two to three years!

Participant teacher (T5)[12]: The students know most of the words in English and some of these need not be explained to them. Some words like 'illustrate', 'define'; they will come to know after being taught for two or three years.

[12] This participant teacher had so far taught for more years than most participants in the study; this opinion suggested an approach to use of language [that respective students were not in favour of] during teaching influenced, perhaps, by a perception of the linguistic abilities of the higher calibre of students generally admitted to this school. The teacher had also taught only at this school since attaining the teaching qualification.

This approach in language use was therefore illustrative of an "inadequate introduction to the students to the language associated with science" (Rodrigues and Thompson 2001, p. 936). The approach potentially presented the students some difficulties in learning physics, and therefore was not helpful in facilitating students' understanding of the characteristic classroom language of science teachers.

Interviews with participant teachers helped shed light on these observations and opinions. A key observation already mentioned in this article is that the newer teachers appeared to have more problems when it came to explaining the physics and certain key words in the specific register of the subject than the more experienced ones. This seemed to have been because the need to be particular about the meanings of non-technical words in the register of school physics and in the common language of instruction as used during teaching was not stressed during their initial preparation as teachers. This was a unanimous report by all participant teachers; the following responses were typical of the submissions:

> Well, in my training I don't remember having looked at specific words and may be giving concern to meanings of certain words. It was not stressed during my training and I just learn of the problem of the use of words during my teaching. (**T1**)
> It was not stressed in college; it is something that you just discover on your own in the field (**T2**).
> It was not stressed but what was stressed was always to write spellings on the board when you are dictating notes and you come up with a new word when you are writing; that one was stressed and a bit of explanations but not so much.(**T6**)

This might be taken as an additional explanation for the already mentioned observation in this article that the newer teachers appeared to have more problems when it came to explaining the physics terms and certain key words in the specific register of the subject than those who had taught for more years.[13] The teachers who had developed the habit of explaining the meanings of words used during teaching therefore did so because of their teaching or other experiences. However, no two teachers had the same set of opinions about their respective use of instructional language in the physics classrooms; the opinions included:

- To meet the marking standards of the examinations council (common with participant teachers who also served as examiners of national examinations);
- To counter the English language problem of the students;
- To enhance the understanding of the students;
- To counter student misconceptions of the word meanings; and,
- As a result peer influence (i.e. discussion on good practices between colleagues teaching other subjects).

How peer influence had apparently also played a role within the need to enhance students' understanding of the concepts taught was revealed in a response immediately below, from participant teacher **T6**.

> For the language, I realized I wasn't always stressing them and *I also got it from the biology people* … one of them said she starts her lessons by telling the students to

[13] This gap in initial science teacher education in the context of this study is because of the tendency to adopt approaches from contexts where language of instruction is not taken as really crucial in teaching and learning science including of school physics (Oyoo 2009).

look into their dictionaries; so we realized most of the dictionaries have all those definitions. (**T6**, Emphasis added)

It therefore became apparent that in being particular about giving explanations of the meanings of the words in the context of use, the teachers who were more experienced seemed to have been influenced by the perceived levels of proficiency of their students in the language of instruction, perceived students' general academic abilities and aptitude for science as well as their conceptions of the difficulty of physics (Porter 2002).

Conclusion and Implications

The analyses presented in this article were to explore physics teachers' manner of use of the instructional language during teaching and their awareness of the possible difficulty of words in their classroom language to students. This was based upon the background that the attention science education research has given to language issues in the teaching and learning of science, in the main, has been within the assumption that the only linguistic prerequisite for successful learning is for the learners to be proficient in the instructional language (Oyoo 2007). This study has revealed that for effective teaching, the teachers need to attend more to the nature of the instructional language of the science classroom.

Teacher education and school curricula in the context of the study reported in this article, have always stressed the importance of practical work, but not the importance of making central the offering of explanations of meanings of words/concepts in the context of use. Based on the findings in this study, it has now become possible to argue that, more than has been the case, use of language for effective communication in the classrooms (as a pedagogical skill) needs to be emphasized in initial science/physics teacher education and in in-service/continuing professional development programmes. Participant teachers shared this view while reflecting on what they had learned by participating in the study; the participant teachers felt that making changes in teacher education at the pre-service level only would delay the necessary change in current physics teaching practices and in effect perpetuate poor outcomes in science in general and physics in particular.

Language use in the classroom was a problem common to all teachers involved in this study, albeit a greater or lesser problem depending on individual experiences. In this study, one participant teacher indicated that her heightened awareness of the need to be careful about explaining meanings of non-technical words during her lessons was the consequence of adopting the practice of colleagues in another science subject. This suggests that peer consultations in the form of collaboration between science/physics teachers, novice and more experienced, and/or with teachers of other subjects would have the benefit of raising teachers' awareness of the challenges of language use during teaching. This will result in knowledge of some of the potentially difficult words or similar words that may have been found to be difficult. Another approach to raising awareness would be to conduct action research in classrooms (see Macintyre 2000), with a friendly teacher sitting through the lessons of a colleague (novice or not) and sharing observations on language used during teaching, similar to the direct observations used to collect data in the research reported in this article. In effect, the classroom teachers will also be researchers of their own practice at the same time. Alternatively, the professional development through teacher participation in subject associations could enhance specific subject content and professional knowledge by addressing the language demands of instructional and assessment tasks in science more explicitly.

In this article, the particular focus on nature of words (vocabulary) in the teachers' classroom language has been with almost no reference to other areas of language as is common in other works widely available in literature. This particular focus is meant to shed light on the role of the instructional language in learning and teaching science, an otherwise neglected area in science education research this far (Fensham 2004; Hand et al. 2010; Miller 2009; Oyoo 2004; Yore and Treagust 2006; Yore et al. 2003).

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