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Influence of Indigenous Language on the Mastery of Scientific Concepts and Vocabulary: A Review and Analysis of the Literature

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Abstract
In different cultural contexts, it has been demonstrated that student proficiency in language may be related to academic achievement and to mastery of concepts and technical vocabulary in school subjects such as science. Where a second language (L2) is the official medium of instruction, the achievement and mastery may be affected by linguistic difficulties arising in the medium of instruction by conceptual difficulty of the subject taught, and additionally, by the interference of the meanings and experiences derived from the mother language (L1). Further, misconceptions can arise where the learner is striving to master simultaneously the medium of instruction and the scientific concepts and vocabulary presented. For example, science content in textbooks and in classrooms in Zimbabwe is usually presented in English, yet the majority of pupils are non-native speakers of English, and thus interference of the mother tongue is predicted, especially for younger students. This article is a review and analysis of the research and theoretical literature on the relationship between language, bilingual communication and education, conceptual understanding and misconceptions in science. Hypotheses are suggested for field testing with Shona, Ndebele and English (L1) students in Zimbabwe.

Introduction
Language is at the heart of children's processes of learning. Vygotsky (2012)) proposes that thought itself may be conceptualized as 'inner speech' while Corson (1988, p.3) argues that "language is the central achievement necessary for success in schooling" and that "children's

differences in language ability, more than any other observable factor, affect their potential for success in schooling" (1990, pp. 77-78). Where children learn through a medium which is not their mother tongue, as is the case in Zimbabwe for most children after Grade 3, there is considerable danger that their learning will be impaired as a result of limited proficiency in the chosen medium of instruction.

In science education, numerous studies have explored learning difficulties that may be linked to language proficiency (Clegg & Clegg, 1994; Germann, 1994; Hewson, 1988; Lee, Fradd & Sutman, 1995; Rolinick, 1990; Nkomo, 1989). According to the findings of these studies, difficulties associated with mastery of the language of instruction manifest themselves in a variety of ways. First, while understanding of science concepts may be achieved, students with limited proficiency in the language of instruction may lack the vocabulary to convey their understanding. For example, Lee, Fradd and Stuman (1995) found that students with limited proficiency in English experienced more difficulty with science knowledge and vocabulary. Secondly, science terms in English may not be used in the same way or with the same frequency in other languages. Thirdly, discourse patterns among cultures differ; in particular, the use of analogies in science may be problematic to some students who may lack experience or knowledge from their culture to relate readily to the analogies. Finally, cognitive or learning strategies used for dealing with learning tasks vary among diverse language and cultural groups, creating, in science education, situations that may not favour the second language users.

In this paper we review the research and theoretical literature on the effects and implications of learning science though a second language. We postulate hypotheses and draw implications for research targeting pre-college students in Zimbabwe.

Research in bilingual education

Research in bilingual education provides useful insight into the probable effect of language on learning. In this section we review studies in bilingual education and the theoretical explanations for the postulated effects of both early and delayed immersion programs. The term 'early total immersion' education relates to situations in which the

initial formal learning experience of a child, i.e. from pre-school or Grade 1, takes a place almost entirely in the medium of an L2. Several studies have indicated that the academic achievement of children learning in such situations is lower than that of their counterparts learning (initially at least) through an L1. Skutnabb-Kangas and Toukomaa (1976) reported that literacy skills in Swedish and Finnish of Finnish children learning through Swedish from the age of 7 or 8 were considerably below both Swedish and Finnish norms when measured by standardised tests some years later. Williams (1994) compared the reading proficiency at Grade 5 of Malawian and Zambian children where the former were taught through their L1 until Grade 4, and the latter were taught in English from Grade 1. Williams' findings indicate higher levels of reading proficiency among the Malawian children in both L1 and L2 than their Zambian counterparts. Research findings such as these have given rise to the labels 'semi-lingualism' (Hansegard, 1975), as describing parallel limited proficiency in both L1 and an L2, and 'subtractive bilingualism' (Lambert, 1977) as describing situations where the learning of a more 'prestigious' L2 undermines a child's proficiency in his or her L1.

In contrast with these finding are the outcomes drawn from the 'early immersion' programmes in Canada. In these programmes English native speaking children from mainly middle class families were taught across the curriculum through the medium of French from Grade 1. Summarising the outcomes of the programme, Cummins and Swain (1986) conclude that "... the results show that, both in science and mathematics, the immersion students perform as well as their English-instructed comparison groups" (p. 38). Further research by Swain and Lapkin (1991) indicates that 'immersion pupils' go on to surpass their monolingual counterparts in L1 language achievement while retaining their L2 advantage. Further evidence of the positive benefits of bilingualism is summarised by both Cummins and Swain (1986) and Baker (2011), with the term 'additive bilingualism' (Lambert 1977) being used to signify the improved language proficiency displayed by the immersion children.

Cummins and Swain (1986) offer several explanations for the contradictory research finding of the effects of early total immersion

programmes. The relative high socio-economic reasons for the success of the Canadian 'immersion children' and their experience of learning through L1 and L2 can be contrasted with that of children from many minority settings who experience learning through the L2 as 'an assault on their identities' and an 'undermining of the children's cultural identity' (Roller, 1988). These explanations are not totally satisfactory. Corson (2006) reports that children from low socio-economic status (SES) Italian, Portuguese and Macedonian immigrant minorities in Australia, learning through L2 English from Grade 1, "out-performed their Anglo-Australian classmates from similar low income backgrounds on a battery of language tests, and in school examinations, even though the latter spoke English as their mother tongue and were matched in non-verbal reasoning with the former" (p. 59). Baker (2011) suggests that "the culture of the language community and the attitudes to schooling of parents may be powerful influences on children's motivation to succeed in school" (p.256). Such parental attitudes and a pride in their community may well result in additive rather than subtractive bilingualism on the part of their children, irrespective of the status of the two languages involved.

Studies of delayed introduction of L2 learning

While learning through the medium of a second language from Grade 1 has often been linked with depressed academic achievement on the part of linguistic minority children, postponing the introduction of the L2 medium to Grade 4 or later has shown improved outcomes. Research based on educational programmes such as the Canadian 'Heritage' programmes (Cummins, 1993) and 'Maintenance' programmes in the USA (Ramirez, Yuen & Ramey, 1991) shows that not only is performance in 'content subjects' improved in comparison with early immersion children, but also, after a relatively short time, performance in the L2 itself. Williams (1994) confirms these findings in respect of reading proficiency in the non-minority settings of Zambia and Malawi. 'Late entry immersion programmes' for majority children in Canada also indicate equivalent performance across the curriculum for both early immersion and mainstream L1 children (Cummins & Swain, 1986).

Research by Zindi (1994), on the other hand, found that scores of native

English speaking children on the revised Wechsler Intelligence Scale for Children (WISC-R) were significantly higher than those achieved by Zimbabwean children learning through English as an L2, even though introduction of English as the medium is delayed until Grade 4. As the greatest difference in scores occurred in the Vocabulary and Comprehension sub-tests, Zindi suggests that the language factor had an influence on IQ performance. However, if introduction of the L2 is delayed until Grade 7 an 'L2 proficiency gap' occurs which has been found to inhibit acquisition of curriculum content (Johnson & Swain, 1994). It would appear that critical factors include the level to which literacy has been acquired in the L1 before a potentially confusing L2 literacy is introduced, and the amount of core L2 instruction there has been before the L2 medium is finally adopted

Interpretation of the research evidence

Cummins (1979) has proposed the 'the linguistic interdependence principle' to account for the rapid development in L2 proficiency and academic achievement in L2 once reasonable proficiency in mother tongue has been achieved. The principle states that: "To the extent that instruction in L1, is effective in promoting proficiency in L2, transfer of this proficiency to L2, will occur provided that there is sufficient exposure to L2, (either in school or environment) and adequate motivation to learn L2," (p.143). The resultant "common underlying proficiency" (Cumins 1981a) is said to make possible the transfer of academic and language skills across languages, and to account for the more rapid learning of second languages by older rather than younger children (Cummins, 1981b). There appears, however, to be a critical level of proficiency in the mother tongue which children must attain before the benefits predicted by the linguistic interdependence principle can be obtained. Where a child is expected to become literate in, and learn through, an L2 before reaching a critical 'threshold level' of proficiency in his/her mother tongue, then detrimental cognitive effects may ensue (Cummings, 1976). The 'thresholds theory' may thus account for the poor reading proficiency in mother tongue and L2 of Zambian Grade 5 children who learn literacy skills in two languages from Grade 1 as reported by Williams (1994), and the unusually low WISC-R results obtained by Grade 8 Zimbabwean children, many of

demonstrates lack of mastery of the subject. For example, Meyer (1995) reviews the work of Dzvimbo (1993) and Clough (1990) who observe a dramatic decrease in the number of Zimbabwean candidates who pass English language at Ordinary level from 80% to 15%. The issues cited for the poor performance are typically shortage of trained teachers, the quality of teacher training, shortage of reading materials, and subject matter (Maposa, 1992). In addition to those issues, Dorsey, Matshazi and Nyagura (1991) note that there is also a lack of teachers with an adequate command of English.

Proponents of language across the curriculum point out that "children's differences in language ability, more than any other observable factor, affect their potential for success in schooling" (Corson, 1990, pp. 77-78). This explanation is meritorious given the fact that language in education takes priority in the activities of thinking, knowing and learning. It is through language that understanding develops in technical fields such as science where it is thought that "language brings our commonsense concepts to a point of engagement with the technical concept" (Corson, 1990, p. 82).

It would appear therefore that the reasons cited for poor academic performance (as tested through the medium of English) fail to note two factors. First, the indigenous Zimbabwean student and teacher do not come from a home environment where English is used as a first language. Second, there are potential problems related to the level of mastery of the mother tongue and to the extent to which the mother-tongue influences the mastery of linguistic structures and concepts taught in the second language. Clegg and Clegg (1994) observe, in so far as science education is concerned, that "learning through a second language is not at all easy. Even when a learner is relatively fluent in the everyday use of a second language, effective learning in the language frequently remains difficult" (p. 1). Furthermore, they assert that pedagogical difficulties, which in first language teaching may be slight, assume a much greater significance in the second language.

The contrasting language performance of children in social and academic contexts noted by Cummins (1981) is explained as emanating from two levels of language competence, 'basic interpersonal language

whom have begun to learn through an L2 before mother tongue literacy has been achieved (Zindi, 1993). Roller's (1988) failure to find evidence of English Shona or vice versa reading skill transfer among Zimbabwean Grade 3 and Grade 4 pupils would also indicate that the required 'threshold level' of reading proficiency in Shona had not been reached before reading in English was introduced. Her choice of instrument, however, may partially account for her findings as reading proficiency in each language was measured through the recognition of odd words in several unrelated lists of words, rather than through the use of connected texts.

While considerable evidence supports the linguistic interdependence principle, the lack of any quantitative description of what constitutes the required threshold level of language competence for additive bilingualism to occur is a serious limit to the threshold theory. Furthermore, Romaine (1995) provides evidence that social, economic, and attitudinal factors together with differences in language teaching methods can also account for different rates of learning through an L2 or the L2 itself.

Difficulties of learning through a second language

There is considerable evidence in the context of Zimbabwe that learning difficulties associated with language are important although they have been subjected to relatively little systematic empirical investigation and analysis. In Zimbabwe the two major indigenous languages, Shona and Ndebele, dominate as the means of social communication in the home. Although the official medium of instruction from Grade 4 onward is English, less than 3% of Zimbabweans use English as a first language. In addition to being the official medium of instruction, English Language as a school subject is very important. For example, it is necessary to obtain a passing grade in the subject in order to obtain a 'full certificate' at the ordinary level. While a candidate may pass five or more school subjects at this level, to be considered for non-manual employment or for admission to institutions of higher learning, it is essential that one of the subjects is English Language.

In spite of this emphasis on the subject, student performance

skills' (BICS) and 'cognitive/academic language proficiency' (CALP). The former level is applicable when the social context provides more clues to meaning, often non-verbal, than are available in normal academic contexts. Although this explanation seems to reflect Zimbabwean experience, Baker (2011) points out that the distinction lacks empirical support. Romaine (1995) argues that research by Scribner and Cole (1980), which showed that levels of literacy in mother-tongue did not affect performance on "CALP-type tests [in L2] ... makes the distinction between CALP and BICS suspect". She contends that "the skills involved in CALP are related to culture-specific types of literacy and are shaped by different experiences with the written language in different communities" (p.268). Romaine's argument appears, however, to be more damaging to the linguistic interdependence principle than to the existence of different spheres of competence which may be developed in different ways, for example, through social contact as for BICS, and through schooling as for CALP.

In the area of science education, limited proficiency in the medium of English presents students with many problems. If, as according to Corson (1988), "Language is the central achievement necessary for success in schooling" (p.3), then learning a new subject through a second language is certainly more difficult than through the home language (Ajeyalemi & Maskill, 2007; Clegg & Clegg, 1994). Therefore, it can be predicted that proficiency in the mother tongue can predict academic proficiency in subjects in the second language.

Language sensitive instruction

These issues appear to be ignored and, in general, there appears to be little attention to language-sensitive teaching, particularly in science education. According to Clegg and Clegg (1994), good language sensitive teaching allows the teacher the opportunity to develop both the subject matter knowledge and language skills together. Such an approach requires teachers to support learners in meeting the demands the subject makes on them. They note that the act of good science teaching may well be an act of good language teaching. This notion is bolstered by Corson's (1988) observation that "development in thinking prowess depends on growth in language. Although language and thought are not identical, they develop together" (p.14). These

observations underscore the notion of science teachers as language teachers (Pereira, 1986). In their observation of physical science lessons in Namibia where English was officially made the official medium of instruction at independence, Clegg and Clegg (1994) not that although most of the activities in science lessons will be in the medium of English, "some, however, such as group discussion, are likely to be in the home language. The question arises, how well does the home language accommodate the demand? ...whether (home) language can accommodate adequately the concept discussed" (p.4). What then is the significance and implication of the mother language as it relates to science instruction in a second language?

The answer to the last question is difficult but it can be attached if we note that language expresses culture (Brown, 1986). Brown notes that world-views among cultures differ and that the language used to express a particular world-view may be relative and specific to that world-view. For example, Osterloh (1986) makes a claim that in traditional cultures such as in the Third World countries more concrete elements are more relevant when compared to abstractions found in many of the more developed countries. Direct contact with objects and immediate intuition are more relevant and thus he claims "gestures, mimicry, and direct perception play a much more important role" (p.83).

Another claim that can be made arising from different world-views is that the home language can 'interfere' in science lessons. Mackey (2005) explains that 'interference' is the use of features belonging to one language while speaking or writing another (p. 308). Odlin (1989) prefers the term 'transfer' to 'interference' as the latter term appears to imply the influence of the mother tongue is always negative. She offers the following definition of 'transfer':

> Transfer is the influence resulting from similarities and differences between the target language and any other language that has been previously (and perhaps imperfectly) acquired.

This definition appears to limit consideration of the phenomena of transfer to the acquisition of new languages. However, the intimate relationship between words and the concepts they embody (Vygotsky,

2012) means that transfer must also be appraised in relation to learning through a new language. Positive transfer in the area of lexis occurs when two languages contain 'cognate' words. The derivation of much scientific lexis from Greek and Latin results in considerable number of cognates among the Romance languages in scientific fields, e.g., conduction (English), conduction (French) and conduction (Spanish). Negative transfer, however, can occur when one word in the mother tongue has two different equivalents in the target language. Thus, the existence of two verbs in Spanish, *estar* and *ser* for the verb *be* in English, is thought to lead to the many errors typically found in the second language Spanish produced by first language English speakers.

A consideration of Shona and English shows that, in the scientific field, there are many gaps in Shona where either there is no Shona equivalent of an English word, or that one Shona term represents two or more terms in English, which in turn embody two or more very different concepts. Thus, the possibility arises that negative transfer may cause difficulty for Shona speakers in understanding some English scientific terms and, in turn, in the concept they embody.

A further complication arises as there are scientific terms that have their technical meaning, and ordinary English usage meaning, and a third meaning that may be derived from the culture-of-origin usage which is different from the first two. Comprehension and mastery problems can therefore arise from conceptual difficulties, from linguistic difficulties and/or from interference. Clegg and Clegg (1994) give examples of concepts such as current, voltage, and resistance as those which may not easily be handled in the mother language (in Namibia). This implies that the language variety of the home "may be insufficient to handle the more academic concepts of the science lesson ..." (p. 7). Rolinick (1990), however, reporting on research where pupils learnt science through their mother tongue, SiSwati, and English, offers evidence that the use of SiSwati "served several important functions including [the] voicing of alternative concepts, clarifying concepts, eliminating misconceptions, and formulating ideas" (p. 168). She comments that "no problems were experienced with the absence of scientific words in SiSwati as the students simply used the English words in conversation" (p. 169).

While this strand of research specifically deals with the issue of verbal discourse and communicative abilities in science classes, written text is often the key source of instructional content. Textbooks are, perhaps, the chief curricular resources with which learners interact and the extent to which textbooks are read with understanding is a concern which readability researchers have grappled with.

Readability and comprehensibility of science texts

Pereira (1986) reports that children who can read simple stories competently and with enjoyment have great difficulty understanding school textbooks. For example, she notes that science is non-fiction and technical and thus science texts tend to be less personal, uses less familiar vocabulary, and introduces abstract concepts. In Zimbabwe, a recent International Association for the Evaluation of Educational Achievement (IEA) literacy study found that at the junior secondary level students "have generally acquired good reading literacy skills... It also shows evidence that students read better the non-scientific expository passages ... than they did those expository passages with a science content" (Moyana, 1991, p.20).

Moyana (1991) notes particularly that Form 2 students had greater difficulties reading and comprehending passages with scientific content than that without. This finding is relevant in that learning in science frequently occurs as students interact with texts, teachers, other students, and materials. Among these, text and teacher discourse are particularly important because the readability and comprehensibility of their messages determine the amount and quality of learning which is likely to occur. In performing their roles, teachers rely on the textbook and sometimes the dominance of the textbooks as the curriculum has been a source of criticism. The content of the textbook becomes the basis of teaches' discourse with their science classes and thus the readability levels of texts can be reflected in the nature of discourse in the classroom. Teachers tend to teach the content of the textbooks but, as Davies (1986) notes, "among the features of the textbook which have been singled out for global criticism are the use of language which is impenetrable and distanced from pupil's own language, and the unnecessary use of technical terms and jargon" (p.101). The particular from of language in the textbook is communicated to students and thus

creating difficulties for learners. In fact, the teachers' or classroom language is often different from the pupil's language but close to the language of textbooks which is characterized by scientific vocabulary and jargon. Watkins research (as cited in Gillham, 1986), showed that in the United States, mathematics delivered in ordinary English to school pupils was more effective at communicating mathematical ideas than mathematics delivered in mathematical English; an observation which appeared true also at the college level.

Gillham (1986) observes that "the language of school subjects is very frequently hostile to communication" (p.4) and more so when the subjects concerned are sciences. Scientific vocabulary includes words which have some meanings within science (which are usually of a technical nature, less familiar, and more difficult due to infrequent use outside the classroom) and other meanings in ordinary language. Science textbooks and in general teacher discourse based on them are often generally above pupils ability to comprehend or to obtain meaning from the text or teacher utterances and hence the significance of readability research. In Zimbabwe, Nkomo (1989) found that the readability of science textbooks was generally above the Form 1 pupils' comprehension level. This implies that, at this level, with the kind of texts they are exposed to, children cannot comprehend or derive meaning from the text they read. Nkomo's (1989) research, based on the scores of cloze and traditional texts, showed that the majority of pupils in the study read science textbooks at the frustration level; the books were too demanding for the pupils' abilities. Interestingly, in the same study, the pupils read English texts at the instructional and independent levels, and compared to science, they achieved more in the tests based on the English texts. In attempting to explain this difference Nkomo (1989, p. 73) wrote:

> It can be argued that the pupil's success with reading comprehension in English language is attributed to reader's factors such as interest, motivation, relevance, previous experiences and attitudes.

The content of the science passages in the texts appeared to be "dry facts which do not seem to activate the readers' limbic system" while on the other hand the English passages "possess higher human interest

element" (Nkomo, 1989, p.75). Some pupils had "ingrained attitudes about science as an impossible subject to understand" even though they realize its relevance to their lives. Although they view science as a prestigious subject "they generally do not think they need to read science resource materials on their own" (Nkomo, 1989, p.80). On the other hand, Nkomo gives perhaps what could be a plausible explanation for observations he makes about ability of pupils to comprehend texts on science and hence their attitudes to the subject.

> It is possible that comprehension in science is hindered by the fact that pupils have to grasp new and abstract concepts in a second language while in English passages, the ideas and concepts discussed are familiar and relevant to Form 1 pupils. The question of the pupils being L2 learners of English can strongly *militate* against successful understanding in science (p. 75).

Nkomo (1989) also notes that there is a general dearth of science textbooks making it difficult for students to "acclimatize themselves to the technical and peculiar language of science" (p.49). However, factors other than linguistic ones, also affect the readability of texts viz. degree of interest of the reader, the relationship between readers' perceptual skills and the text, and the extent to which readers can relate the ideas in text to own experiences, i.e., relevance. On the latter point, Harris and Sipay (1979) point out that children read not to improve their minds but to solve real-life problems. It is clear that the readers' prior knowledge and experience lessen reading difficulty and enhance the degree of comprehension. The knowledge obtains principality from readers' linguistic and cultural backgrounds.

Alternative conceptions, culture and language

The importance of language in the learning of science is undoubted. It can better be appreciated by reviewing the way children are believed to learn science. The presently influential social-constructivist view (Glasson & Lalik, 1993) assumes that before children go to school they have developed concepts from their cultural experience and in their language. Their conceptions may not necessarily be 'correct' and sometimes are at variance with accepted notions in science. Science educators are therefore concerned with assisting learners to alter their

misconceptions or alternative conceptions. The assumption, in this conceptual change theory, is that currently held conceptions are important to learning but may have to be changed in favour of the more scientifically acceptable conceptions (Eylon & Linn, 1988; Strike & Posner, 1992).

In order to effectively bring about conceptual change, researchers expend considerable effort in seeking to provide an account of the sources of the prior conceptions. For example, Hewson (1998) demonstrated how children in South Africa constructed scientific knowledge according to their prevailing cultural beliefs acquired through the first language. According to Bowers and Flinders (1990) "the language of the culture provides the shared set of pre-understandings that will guide the interpretations the individual makes of new experiences, for the most part these pre-understandings will not be part of what an individual is explicitly aware of" (p.32). In a recent study with four language and culture groups, Lee et al. (1995) revealed important and distinct patterns of science knowledge, science vocabulary, and cognitive strategy use which they linked to the cultural background. While noting that students whose first language was English demonstrated superior science knowledge and vocabulary expressed in that medium, they also observed the verbal discourse patterns among students and their teachers in completing science tasks. They noted that although the monolingual (English) teachers and students relied heavily on verbal communication, the other groups for whom English was not the first language, "used non-verbal communication of hand motions and gestures to enhance or supplement verbal expression" (p. 807). Further, some of the students simply lacked the specific vocabulary to convey precise meaning and hence demonstrated greater difficulty with science knowledge and vocabulary. These students experienced some difficulties linked to the fact that "terms used in English are not necessarily used in the same way or with the same frequency in other languages. In addition, cultural expectations for interactional styles and discourse patterns also have a role in students responses" (Lee et al. 1995, p. 869).

Use of analogy and metaphoric discourse in science education

All in all, the cultural and linguistic knowledge that students bring to instructional tasks have an important role as demonstrated by Lee et al. (1995). This cultural and linguistic knowledge is particularly important since in science education, metaphors, analogies, similes, and models are frequently used in attempts to enhance students understanding (Dagher, 1995). Often, inability of students to understand may be due to the use of unfamiliar metaphorical frameworks "than with individual intelligence and motivation" (Bowers & Flinders, 1990, p. 31).

Dagher (1995) opts to use the term 'analogy' to encompass similes, metaphors, and models. An analogy is, according to Dagher, a familiar phenomenon (i.e. the source) similar to the unfamiliar phenomenon (i.e., target) to be explained. The assumption is that metaphors provide schemata, i.e. conceptual frameworks, for understanding science tasks and content (for detailed treatment, see special issue of the *Journal of Research in Science Teaching* edited by Good & Lawson, 1993). However, Lee et al. (1995) make the pertinent observation that students from other cultures may lack personal experience or personal knowledge related to science tasks. There lies a possibility, therefore, that the use of analogy or metaphor, or model in science instruction may, for these students, serve to mystify rather than clarify science concepts.

Analogies are frequently culture specific and, thus, many which are helpful to Western students may actually impede the understanding of students from other cultures in the learning of the concepts targeted by instruction. In addition, the language in which the analogy is expressed may result in students less proficient in the language having additional difficulties in interpreting the link between sources and target phenomena in the analogy.

Implications for science education and research

In summary, there is considerable agreement that proficiency in the language of instruction is directly related to academic achievement (Clegg & Clegg, 1994; Corson, 1988; Lee et al., 1995; Rolinick, 1990).

On the other hand research in bilingual education on the effect of immersion programs provides contradictory evidence as to the factors which render learning through a second language an additive or subtractive experience (Baker, 2011; Cummins & Swain, 1986; Lambert, 1977, Skutnabb-Kangas & Toukomaa, 1976; Williams, 1994). Factors which are cited as important include the level of development of the L1 at the time instruction in the L2 is commenced, the extent to which use of the L2 is seen as 'an assault' on the learners' home culture and the status of that culture relative to that of the L2, and the assimilating or pluralistic aim of the education. In so far as science education is concerned, Clegg and Clegg (1994) observe that "learning through a second language is not at all easy. Even when a learner is relatively fluent in the everyday use of a second language, effective learning in the language frequently remains difficult" (p.1).

A further reason for lack of success in learning science through an L2 may well lie in the phenomena of 'negative transfer' (Oslen, 1989). For example, consideration of the lexis of Shona and English shows that in scientific fields there are many gaps in Shona where either there is no Shona equivalent of an English word, or that one Shona term represents two or more terms in English, which in turn embody two or more very different concepts. Thus, negative transfer may cause difficulty for Shona speakers in understanding some English scientific terms and, in turn, in the concepts they embody. Indeed, it has been found that junior secondary level students in Zimbabwe "understand better the non-scientific expository passages... than they did those expository passages with science content" (Moyana, 1991, p.20). Limitations in the language proficiency of a learner, including lexical gaps such as those existing in Shona, are particularly important to the process of learning as viewed from the social constructive philosophy, where language serves as, perhaps, the major tool in the process of guiding students' constructions. Glasson and Lalik (1993) posit that "from our social constructivist view, language can be used to stimulate adaptive cognitive activity. Students use language to represent their current understandings as well as the process by which they develop such understandings" (p. 188).

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