Third Misconceptions Seminar Proceedings (1993)

Paper Title: Tried by Words: Verbal Misunderstandings in Science Teaching
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Keywords: Concept Formation,,,Comprehension,Scientific Concepts,Misconceptions,,,
General School Subject: Physical Science
Specific School Subject: Physics
Students: High School

Macintosh File Name: Rutherford - Science Teaching
Release Date: 9-15-1994 I

Publisher: Misconceptions Trust
Publisher Location: Ithaca, NY
Volume Name: The Proceedings of the Third International Seminar on Misconceptions and Educational Strategies in Science and Mathematics
Publication Year: 1993
Conference Date: August 1-4, 1993
Contact Information (correct as of 12-23-2010):
Web: www.mlrg.org
Email: info@mlrg.org

A Correct Reference Format: Author, Paper Title in The Proceedings of the Third International Seminar on Misconceptions and Educational Strategies in Science and Mathematics, Misconceptions Trust: Ithaca, NY (1993).

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Tried by Words: Verbal Misunderstandings in Science Teaching

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INTRODUCTION

Scientific language is frequently considered to be one of the major hurdles for novice scientists. Unless they can be initiated into the language and culture of science pupils will not progress even to competence in the field. The problem seems to be common to all countries and the decrease in the number of children studying science coupled with a lack of public understanding of science is causing concern in many places (Couper, 1993).

In many parts of the developing world the medium of instruction is not the students' home language. The reasons for this have been documented elsewhere (e.g., Rutherford and Nkopodi,1990), but what is of importance here is the fact that in countries such as South Africa, with many vernaculars, it is unlikely that the medium of instruction will be the mother tongue of the majority of the population in the foreseeable future.

In South Africa, although only about 5% of the population is English first language speaking (maybe 2 million out of a total population of 37 million - 1991 census figures) the medium of instruction seems likely to be English for at least 90% of the children. The problems of scientific language are therefore exacerbated by the problems of second language learning. This paper looks briefly at some of these problems and some of the initiatives which have been taken to ameliorate the difficulties.

LANGUAGE, CULTURE AND THOUGHT

The language we speak consists not only of words (vocabulary) and sentence constructions, it includes a hidden agenda of unspoken assumptions and expectations. We

subconsciously assume that the person to whom we are speaking has the same background and underlying beliefs as ourselves, particularly if they appear to be fluent in the language we are speaking.

If this is in fact the case then communication will take place, if it is a false assumption, incomprehension and often antagonism is the result. At the very least the person to whom we are speaking will be disinterested and unlikely to pursue the conversation. Our mother tongue therefore includes a whole rag bag of cultural and traditional values and beliefs. When we are talking to a person from a different linguistic and cultural background we cannot assume that they will understand the inferences and assumption implicit in our speech, no matter which language we are speaking. The most recent theories of second language learning (Maley,1989) emphasise the need for the learner to have some understanding of the cultural background of the people who speak that language as a mother tongue. The day of the language laboratory, drill and practice is probably over and the emphasis is on communication before grammatical accuracy. Krashen (1981), a respected authority on second language acquisition, emphasises the need for the input to be comprehensible for learning to take place.

So different people speak different languages and communication does not depend solely on what we say. However these common or shared assumptions can transcend language differences. It is often easier to talk science with another scientist whose mother tongue is different to yours than to try to communicate science to a non - scientist who shares your native language. The culture of science is the important factor and the shared disciplinary knowledge makes communication more effective.

In other words the intra-cultural differences (where culture refers to the norms and beliefs of the society in which we were brought up) can be greater than the inter-cultural

differences. The disciplinary culture over-rides the societal culture.

What is the relevance of this to teaching science? To quote Kurland,1982,

> `We cannot ... expect students to articulate an understanding of scientific concepts until we assure ourselves that they are functionally literate in this (scientific) language'
>
> Kurland, 1982

This means therefore that to improve the level of scientific understanding we must consider not only the outward language spoken but also the assumptions and inferences of scientists - we need to implant science in the sub-soil of the minds of our pupils.

SCIENTIFIC LANGUAGE

The difficulty of the spoken or written language of science for novice scientists has several aspects, apart from the hidden assumptions mentioned previously. These can be grouped into the vocabulary, the pronunciation, the syntax and the density of content. Each of these will cause more or less 'noise' for the science student depending on the level of sophistication of the learner and the teacher and the development of their language as well as their scientific skills.

Briefly looking at each of these factors in turn:

Vocabulary

Scientific vocabulary may be divided into three groups:

a. Everyday words used in a science context
b. Portmanteau words
c. Science specific words

Of these three groups the last one causes the least difficulty - it is often just a case of learning a new word, its meaning (which may indeed be problematic to explain in the vernacular) and how to spell it. The other two groups can

cause major problems even, or especially, for English first language speakers.

a. Everyday words

In a large study with Scottish children, Cassels and Johnstone (1985) identified a group of words which are used as common currency in scientific discourse but are frequently not understood by children. Such words include 'linear', spontaneous and so on. Moreover the words are sometimes taken to mean the exact opposite of their real meaning - science teachers assume that their pupils understand these words at their peril!

b. Portmanteau words

This type of word has several meanings,

> "You see it's like a portmanteau - there are two meanings packed up into one word"
>
> Lewis Carroll, Through the Looking Glass

These words cause more or less difficulty according to the level of education of the student but it is unsafe to assume that the learner has the same meaning in his mind as the teacher. The word 'field' has connotations of a green level space where animals graze - it is a two dimensional area. This can cause problems with magnetic, electric and gravitational fields which are space filling and solely a construct of our imaginations. Energy is another word which has several common meanings and, moreover, is very difficult if not impossible to define in a scientific context. The list of portmanteau words is considerable, however, fortunately, for fluent English speakers, the context defines the requisite meaning and the majority of these people can operate with several meanings side by side . The teacher must however make the dual meanings explicit in the required context.

PRONUNCIATION

Scientific words are pronounced in a way which has to do with the roots of the word and with common agreement.

However, as with many words in English they are not always pronounced in a way which is obvious to a novice. Moreover, if the teacher has only seen the word in a text book he or she may also mis- pronounce the word so that when spoken by someone else the learner does not recognise it. The stress on an incorrect syllable, for example alibi rather than alibi can cause confusion.

One example which was found in a second language situation was 'bus 'n banner', how many English first language speakers would recognise this as a bunsen burner? Even with some nominally first language speakers mis-pronunciation can occur - an example of this was a chemistry teacher who confused another chemist by speaking of 'aneons' and 'kayshuns' instead of an-ions and cat-ions. In many schools in Africa the teachers are also second language English speakers and may not even speak the same African language as their pupils which compounds the problem.

SCIENTIFIC WRITING

It used to be common parlance to talk of 'the scientific register' as something which could describe the differences between scientific and everyday language. The term has fallen out of favour with many linguists but the descriptors used are useful to describe some of the features of this way of writing. Scientific writing is

- logical
- hierarchical
- impersonal
- passive

In addition it usually has long sentences with many embedded clauses, uses many logical connectors and is full of ellipsis. If the usual readability tests are applied to science text books, the nominal level is almost always much too high for the intended reader. Fortunately the specialised vocabulary contributes much to this so that the situation is not as bad as it might appear to be initially. Nonetheless

science texts are very dense and particularly for a second language speaker frequently impenetrable. In addition, science texts usually have many diagrams, graphs and tables. Novice scientists tend not to look at these as part of the text but as separate 'decorations'.

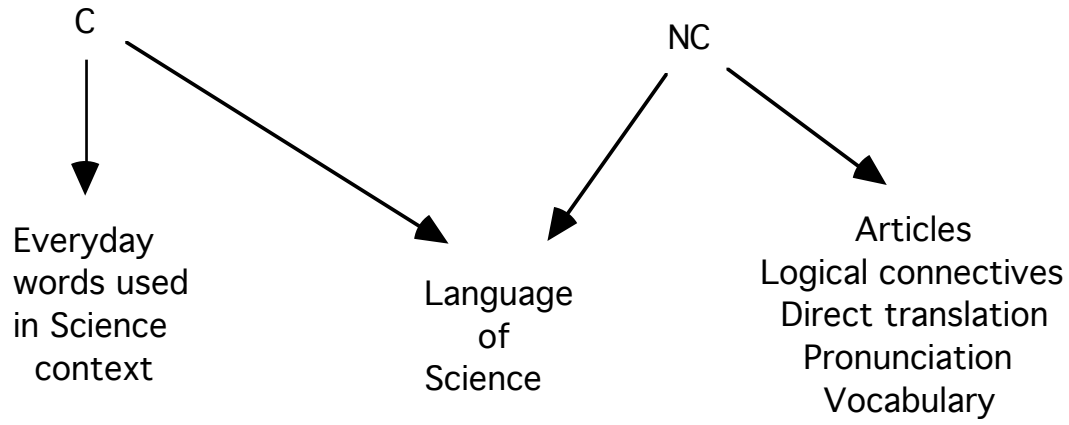
The language of science is indeed a second language, and, for those taught in a language which is not their mother tongue it may well be a third or fourth language. Whilst there is some evidence that those science students who have established the science concepts in their vernacular can, without too much difficulty, transfer these into another language, particularly if the second language is in the same language group (Ho,1982), there are many students who for one reason or another are taught science in a language which is not their mother tongue and in which neither they nor their teachers are really fluent. This is the situation in much of South Africa and the rest of this paper looks at some studies investigating the problems and initiatives to address them.

FINDINGS FROM STUDIES LOOKING AT SCIENTIFIC LANGUAGE

Fig 1 shows diagrammatically the problems identified from an initial classroom survey with different language combinations of teachers and pupils, (Nkopodi,1991). All students had some problems with portmanteau words and the language of science and in addition the learners who were not competent in English experienced many more.

Fig 1

LANGUAGE PROBLEMS



C = competent in English
NC = not competent (mostly E2L speakers)

Many of the African languages make very little use of logical connectors, the words do sometimes exist but are so rarely used that they have little meaning when used precisely in a scientific context.

Many of these languages do not use articles, for example 'a' and 'the' are the same word, so that the difference between 'a metal' and 'the metal' is not clear. This means that the subtle difference between the sentences

'Copper is a metal which conducts electricity'

and

'Copper is the metal which conducts electricity'

is not possible in the vernacular and the second of these two sentences with the implication that copper is the only metal that conducts electricity is taken as being the same as the first. The understanding that it is one of several conducting metals may well be established but cannot easily be verbalised in the vernacular. Transcripts of classroom interactions indicate that the indiscriminate use of articles is not usually a bar to understanding in the spoken traffic of the lesson but may well be a problem when written by a

second language speaker and marked by a native English speaker.

A further problem with second language speakers who are not fluent in English is that they frequently try to translate into the vernacular with confusing results (Nkopodi and Rutherford 1993). However in the same investigation, teaching materials on the topic of pressure have been designed by an English second language speaker for Std 7 pupils. The worksheets for the pupils were written with an appreciation of the language problems but even so it was found that the pupils could not perform the experiments until the teacher had translated the instructions into the vernacular. Once they understood the instructions they were enthusiastic about the activities and performed them competently. This would indicate that translation with discretion is a possible solution.

As mentioned previously, pronunciation also causes problems, two examples where non-native speakers cannot differentiate between two words which sound similar but have very different meanings are 'exerts' and 'exists' and 'extend' and 'extent'. The latter pair were very problematic for post graduate students! However the sort of confusion caused by pronunciation of such words as 'pen' and 'pin' and 'bed' and 'bird' is usually clarified by the context.

The final area of difficulty which should be mentioned again in this context is vocabulary. Whilst the idea of linguistic determination is no longer accepted, it is true that some languages are more developed than others. It is possible to develop all languages to a degree where any subject can be taught in them but the vocabulary of science is difficult to invent in a meaningful way. In one African language the word coined for **oxygen** means, if strictly translated, a kind of vegetable marrow. This is by no means an unusual situation. More recently what has tended to happen when a translation is required is that the English word is used with a prefix or a suffix to fit it into the structure of the language for

example an **ion** was translated into **ayone** (pronounced aye - own - ne) in N Sotho.

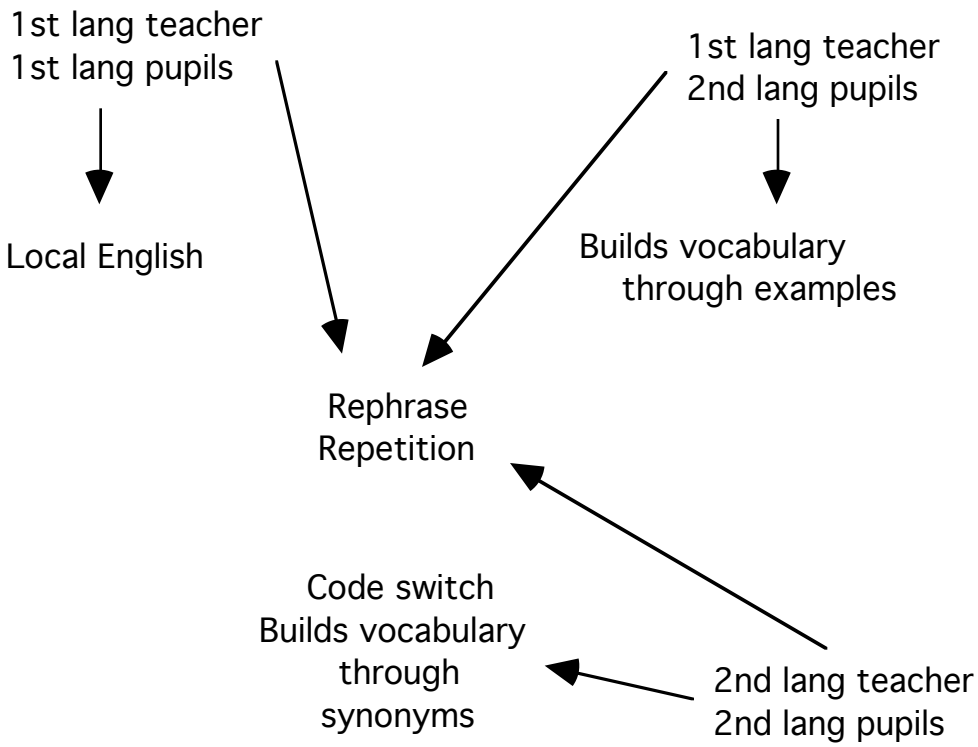
STRATEGIES FOR TEACHING IN A SECOND LANGUAGE

Some recent research in classrooms in South Africa identified different strategies used in classrooms with different teacher/pupil language combinations. Lessons on pressure were tape recorded for English first language teacher and pupils, English first language teacher and English second language pupils and English second language teacher and pupils.

Fig 2 shows some of the strategies that were identified. Not unexpectedly, the English first language teacher with a class of English second language pupils was the most sensitive to problems of language. When the teacher is also a non-native speaker of English then there are obviously both advantages and disadvantages - he can use local examples and can code switch where appropriate but on the other hand may not have sufficient proficiency in English to develop the pupils' command of scientific English to a degree sufficient for further study in English.

Fig 2

LANGUAGE STRATEGIES



An interesting anecdote comes from the experiences of two students during teaching practice for the post graduate higher diploma. Both of the students had studied for their first degree at the same university (Wits) and were equally competent in their subject. One was white the other black. These students went for teaching experience to the Wits Rural Facility in one of the very rural areas of the NE Transvaal. Neither of students spoke the same vernacular as the school pupils. The white student had no problems because he was not expected to a) understand or use the local language nor to b) use local examples. The black student on the other hand found it very difficult since he was expected to both understand and use the vernacular and to be conversant with the local culture.

STRATEGIES USED WITH UNDERGRADUATE STUDENTS

Another research project aimed at improving both the language and the subject competence of second year dental students is nearing completion. The student records at the end of the first year were collected and the students ranked. All the students took a test which was designed to establish a measure of their language ability at the beginning of the second year and some of them, mainly E2L speakers, attended extra tutorials where a programme aimed at improving their language skills was implemented. This programme included such things as role play, group discussions, analysis of texts and pictures and other techniques in a structured way. At the end of the year all the students took a post test on language skills as well as normal end of year examinations. All students who had attended the extra sessions had improved their ranking on end of year assessments and, in addition had gained more points on the pre-post test comparison. The results of this study have not yet been fully analyzed but the tentative conclusions are sufficiently positive for the same techniques to be attempted with chemistry E2L undergraduates by a masters student teaching at another tertiary institution.

Finally an integrated support programme for engineers (WISPE) at the University of the Witwatersrand included a language and communication (L/C) component. At the start of the course the students were given a questionnaire to find what they thought their needs were. This was done for several consecutive years and the results were always very similar- the students did not think that they needed English lessons since they had all passed English at matric, but they did think that they needed help in using the prescribed text book, in listening and taking notes in lectures, in writing reports and in managing their time. On the other hand, the lecturers felt that the students command of English was poor and that they needed 'English lessons'. The L/C course was therefore designed to integrate the needs identified by both

students and lecturers into a context which was felt by the students to be relevant and appropriate. Students were given structured exercises based on the content of their physics course and aimed at improving specific language skills. Because of the need for both science and language expertise, the course was co-developed and originally team taught by a physicist and an English specialist (Kotecha and Rutherford, 1991). Whilst it is difficult to ascribe increased success to any particular aspect of a course with the degree of integration which was a feature of this one, it was very noticeable that the students on the course were identified by other lecturing staff as being more articulate in presentations and more competent and confident in using their textbooks than others.

CONCLUSION

The needs of E2L students in science are fairly well established and a variety of techniques for addressing these needs are being developed. Research projects at present being conducted will greatly aid the development of integrated courses to improve the language and communication skills of science students.

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