Learning Science in a Second Language: Problems and Prospects

Srinivasiah Muralidhar

Abstract

One of the issues identified in a recent study of science teaching and learning in Fiji's primary and secondary schools was the problem faced by students in coping with scientific terminology, and in expressing ideas in their own words (Muralidhar, 1989). In this paper, some examples from the study are used to illustrate the extent of the problem and to discuss the implications for teaching and learning science. It is argued that the quality of communication is an important factor in promoting the understanding of science, especially when the main sources of information for the majority of our students are the textbook and the teacher.

Introduction

In recent years, a number of studies have addressed the complexity of the language of science in the classroom. If we pause a little and think of what the majority of pupils have to cope with in science lessons, we will then begin to understand the background to this complexity. The pupil has to cope with: his or her own language while writing notes or completing homework; teacher's spoken language; the language used in curriculum materials and textbooks; teacher's written language on the chalkboard, handouts and tests; the terminology of science; and the disparity between the meanings of the same words when used in everyday language and when used in the context of a science lesson.

Some of these issues have been explored by scholars in the context of native speakers of English (Barnes, 1969; Bell & Freyberg, 1985; Gardner, 1974, 1977; White, 1988). These studies show that even students whose mother tongue is English experience difficulties in dealing with the specialist terminology used in science and in coping with the language demands and assumptions made by science teachers and writers of curriculum materials. This being the case, the problems faced by students learning science in a second language are bound to be even greater and more complex.

To illustrate the difficulties experienced by native English-speaking pupils in coping with scientific terminology used in textbooks and examinations, Greenwood (1990) cites two examples:

* In a study of the language of O-level chemistry, only five percent of the pupils could correctly use terms such as: pungent, justify, attributed, dense, concept, residue, converse, constituent.

* Of the pupils who answered the following question, only 34 percent gave the correct response:

Which one of the following requires a non-aqueous solvent to dissolve it?

a) salt	c) sodium nitrate
b) sugar	d) sulphur

But when the question was changed to "Which one of the following requires a liquid other than water to dissolve it?", 49 percent of the pupils in a comparable group gave the correct response. Thus, just by replacing the term "non-aqueous" in the question, the success rate improved by 15 percent.

We can think of a number of instances in science, and even in other subjects, where pupils' failure to respond correctly to a question is mistakenly attributed to their lack of understanding the concept. To a large extent, this is a result of the disparity between the language used by the teacher of science and the language used and understood by the pupils. Very often teachers take it for granted that the language used to state rules, express concepts or define terms is self-evident, and may fail to notice that what seems simple and clear to them may be hard and vague to their pupils.

The Fijian context

The above examples were cited to emphasise that it is not just the non-native speaker of English who has difficulties with the language of science and that the language needs for learning science are more than simply the acquisition of an adequate level of general English. Before moving on to illustrations from science lessons in Fiji, a brief outline of the structure of schooling in Fiji is in order.

The main languages spoken in Fiji are Fijian, Hindi and English. Except for the initial years of the primary school, the medium of instruction at all other levels is English, and it is also a compulsory subject of study. Students also have the opportunity to study Fijian, Chinese, Hindi and other Indian languages at primary and secondary levels.

Children in Fiji enter the first year of the primary school at a minimum age of five years and eight months, and follow successive stages as shown below. In some schools, years 7 and 8 are the last two years of the primary system, while in others, they are the first two years of the secondary system.

	(Primary					)						
Year/Grade:	1	2	3	4	5	6	7	8				
Year/Grade:							7	8	9	10	11 12	1
							(Secondary				)	

The science curricula presently followed in Years 1-13 were all developed locally, and are as follows:

* Years 1-6 Elementary Science (Primary)
* Years 7-10 Basic Science (Primary/Secondary)
* Years 11-13 Choice of Physics, Chemistry, Biology (Secondary)

Study of a science curriculum in action

The illustrations provided in the next section are from a recent study (Muralidhar, 1989) of the implementation of the Basic Science curriculum in Fiji's primary and secondary schools. The study focused on: the activities and experiences of teachers and students in science lessons; the curriculum materials in use; the implementation of the curriculum in relation to the philosophy and aims of Basic science; the factors influencing the work of students and teachers; and the perceptions and concerns of teachers and curriculum officers in relation to curriculum practice.

The principal methods used in this holistic study were: intensive participant observation in classrooms; analysis of curriculum documents and materials; discussions with students during activity-lessons; and interviews with teachers and curriculum officers. In addition, there were several unplanned interventions on the part of the researcher to capture the meaning and essence of students' and teachers' actions during lessons.

Classroom observations spread over two terms and covered seven secondary and five primary schools. In all, 289 science lessons taught by 32 teachers in 34 classes were observed.

Illustration from science lessons

A Question without words

Figure 1 shows a question given in a Basic Science test for Year 7 students.

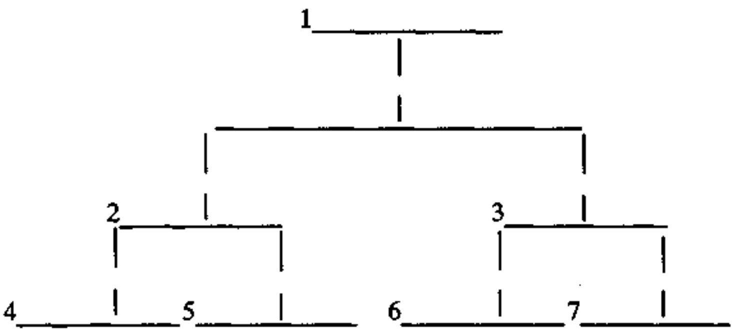

Fig.1 Question on test paper

When I looked at the question I had no idea of what the students were supposed to do; the question did not have any statement or instructions. But when I went round the class I discovered that students knew what they were supposed to fill in: 1 Substances, 2 Living, 3 Non-living, 4 Plants, 5 Animals 6 Natural, 7 Man-made. I then realised the conditioning the students had gone through; they could respond to questions even without statements. The teacher casually told me that her pupils knew what to write in the blank spaces.

When the teacher was going over the answers to the question, she asked the class for an example of a natural object. One student mentioned "grass", but this example did not fit into the classification system given in the book which divided living things into plants and animals, and non-living things into natural and man-made. Therefore "grass" could not be identified as a natural object; the answer was not acceptable to the teacher. One can only speculate about the confusion caused in the mind of the young student.

When I was speaking to the teacher a couple of weeks later, I asked her if she was justified in rejecting the student's answer. After some discussion she realised her mistake and undertook to bring it up in the class.

Words Do Matter

In a Year 7 class, a teacher wrote the following questions on the board and asked the pupils to answer them in their books:

1 Explain what is matter?
2 Name the three states of matter
3 Write one sentence for each to describe the difference between solid, liquid and gas [sic].
4 Classify these substances into solid, liquid and gas. Stone, foam, plastacine [sic], beer, rubber, air, hair, smoke, water, paper, lemon juice, oxygen.
5 In which state of matter are [sic] able to move about most freely [sic] solid, liquid or gas.

When I went round the class to see what the students were writing, I discovered that they were having difficulties, particularly in answering questions 1, 3 and 4. In answering Question 1, they were trying to reproduce the standard statement "Matter is anything that occupies space and has weight". Many did not know what "occupies" meant; they were also struggling with the spelling of the word. This is how they spelt

"occupies":

occupis, ocours, ocopaises, oxpaiyea, octopases, octopaseds, occurpies, occupiece, occupie, ocipies, occuprece, occypies, occpic, occpiss, occupuis

In Question 3, some students had difficulty understanding the question while others struggled to frame sentences. In question 4, the term "classify" posed a problem for a number of students. Only towards the end of the period did the teacher realise that something was missing in Question 5, and inserted "the particles" between "are" and "able". I am not sure if it made any difference to the students.

What the students were going through graphically demonstrated to me the barrier created by terminology; the very terminology taken for granted by science teachers. I was not able to find out what effect students' responses had on the teacher or how he reacted to them. But what came out clearly was that the teacher was oblivious to the difficulties students were having in answering the hastily written questions.

One of the questions in a test given to a Year 7 Class was:

> Explain the following terms:
>
> (a) soluble
> (b) insoluble
> (c) solvent
> (d) solute

Of the 34 students who took the test, only 12 answered all the four parts and 16 did not attempt any part. The following are the 12 responses to part (d):

* the solvent that dissolves
* mean something that dissolve in solid
* the solute that dissolve in solvent
* means anything that dissolves in solid
* something hard

* mean when something can dissoved in water
* something were dissolve in solid
* is something that dissolve in solution
* something con dissvels in solvent
* had something like solvent
* is something hard
* solid did not barn

Of the eight students who tried to use the word "dissolve", only three used the word in a scientific way. Once again, the responses indicate the complexity of the language of science and the problems our students face in understanding and expressing the meanings of technical terms. An additional concern is that 16 students in the class did not respond to the question at all. Perhaps they did not know what to write; one can only speculate. It seems to me that instead of asking younger students to "define" and "explain" terms, teachers need to think of better ways of testing the understanding of scientific terminology.

It might be argued that the use of specialised terms is basic to the study of science, and without them, the subject would lack the necessary linguistic means to exist (Greenwood, 1990). While there is some justification in the claim, students will have very little understanding of the terms and definitions introduced in science lessons unless they have clear and relevant examples in their minds.

Teachers' Questions and Students' Responses

In the majority of lessons I observed, the main function of the questions asked by teachers was to test for pupils' ability to recall facts. Questions were largely convergent in nature, and because of this, students' responses were restricted to one or two words, completing teachers' statements, or to saying yes/no. Even where questions required some thinking to be done, students were not given time to process information and formulate the answers. The following extract from a lesson transcript illustrates this point:

T: Now, do you think decomposers can photosynthesise? decomposers - can they photosynthesise? or can they perform photosynthesis? yes or no?

S: no

T: no! just think. When the decomposers are breaking down dead decayed things or causing things to decay, what are they feeding on? (without waiting for a response) the decayed matter, isn't it? dead decayed matter. So, if an organism feeds on dead decayed matter, do you think it is er...can photosynthesise? Shalini?

S: yes

T: Yes! they can't isn't it? because if they feed on dead things, they are not utilising sunlight, carbon dioxide and water. So, they cause decay and therefore feed on decaying matter. So they are not grouped or identified as green plants right? or producers.

(Year 9 Class)

Teachers were generally preoccupied with the "right" word, the "correct" answer or the "proper" definition, but very few attempted to explore how students arrived at a particular answer or whether they understood the meaning of the word or the definition.

T: (reads from the book) How do plants trap sun's energy? How do they trap it? What happens when the sun shines on the leaf? Salma? Alisi? You don't know! (a little annoyed) Raijeli?

S: photosynthesis

T: Yes - good - through photosynthesis

(Year 10 Class)

T: What is volume?

S1: To measure objects

S2: Amount of space taken by an object

T: Good boy

(Year 7 class)

T: Let's look at the answers to questions. Question one: when solid wax is heated, it______. I had one blank here, one space to fill it in there, right? Yes Lepani?

S: changes to liquid

T: It changes to liquid. I got one space here - I have already gave [sic] marks to people, but anyone can tell me any better words apart from [this] - one word - yes?

S: it melted?

T: It melted, yes, or it melts, right? I was looking for

SS: melts, yes

T: When solid water is heated, it melted or it melts. This is the word - so if you have got this one, that is the best answer. Other people have written: it changed to liquid - I have given you half mark or something like that - right?

(Year 7 Class)

<u>One-way Communication</u>

Some teachers even did most of the "observations and "interpretations" for students, thus robbing students of the opportunity to express what they saw and did, in their own words. The following extract refers to a Class 7 activity in which hydrochloric acid is added to pieces of coral:

T: If your coral was very white and clean, you must have seen - you may have seen tiny pieces of coral breaking off and moving around in the test tube with the bubbles as it rose up - yes?

SS: yes

T: Okay - that means some sort of what was given off - bubbling off? bubbles must have been made of something.

SS: air, air

T: Air?

SS: gas, gas,gas

T: Gas - right? Air has many kinds of gases in it but what particularly must have been coming out of that test tube was

SS: gas

T: That means, pieces of coral must have been eaten away by the acid to form

SS: gas

T: gas - so, this definitely must be a chemical change.

In another lesson, the same teacher is discussing the heating of water in a beaker:

T: Okay - now - the [activity] we did in which we heated a beaker of water, we noticed [bubbles] of what coming out?
SS: bubbles
T: bubbles coming out - bubbles definitely were of
SS: air, air
T: that suggested that water has
SS: air, air
T: Air - when you heat it [water], it drives the air out - okay?
SS: yes

Activity-lessons in science provide excellent opportunities for teachers to encourage oral and written communication among pupils. But as these extracts show, teachers tend to have a monopoly on words and fail to know their students' thoughts and ideas. In the first extract, the teacher was certain that the "bubbles must have been made of gas", and in the second, that the "bubbles definitely were of air". But, for the pupils it was just "bubbles"; how would they know the difference?

Stress on Uniformity

The approach used by the majority of teachers did not encourage students to express their ideas freely. This was especially the case in primary schools where teachers wrote everything on the board for students to copy; the activities, the diagrams, the answers, and even the date. Pupils could write in their books only after the teacher was satisfied that they were clear about what to write. I became aware of the seriousness of the problem in the very first lesson I observed in the study. The teacher called on the students to read out their answers to some questions given for homework. After pointing out some of the errors, the teacher removed the cardboard sheet which was covering the answers she had written on the chalkboard earlier. The students immediately started erasing their answers and began copying the teacher's answers from the board. When I questioned the teacher about this practice she said, "I have got the habit of marking each work they do, and so, if they all have the same answers, then the work is easier as far as the marking is concerned". She justified her actions by saying that her heavy teaching load and the large classes she was teaching did not allow her enough time to go through students' books in detail. This is only one of many such observations.

Another factor which inhibited students' self-expression is the design of the Basic Science curriculum materials. Most of the exercises and record of activities in Pupils' Books are in a pre-set format requiring students either to complete sentences or to fill in blanks. Likewise, the recipe-style and over-instruction adopted in Teachers' Books did not encourage teachers to move beyond the book and develop creative approaches suitable for their students. Because of their inadequate background in science, most primary teachers stuck rigidly to Teachers' Books and presented lessons, with very little variation.

Discouraging Students' Responses

In many lessons, students were ridiculed if their responses were not in agreement with what the teacher was looking for; it was as if the student was on trial for a grave crime. The following exchange took place in a Year 7 class during the lesson: Why is Sea Water Salty?

T: Where does the salt in the sea water come from? Think about it - put your hands down - where does the salt come from? Yes?
S1: comes from the washing
T: washing?
SS: no
T: comes from the?
S1: women washing the er...
T: (raising her voice) no - no - you are talking about fairy tales - we are not talking about fairy tales. We try and find the explanation for that ha? Fairy tales - no - no - we are not interested in fairy tales - this is not a English class - this is a science class ha?
SS: yes
T: we try and find out
SS: yes

To start with, this group of students had considerable difficulties reading and writing English. The attitude of this teacher made matters worse; the more she forced them to come out with responses, the more they shrank and withdrew - they were scared to open their mouths. "We try and find the explanation for that" was a pretence; this is how the students (and the teacher) found the explanation:

Where does this salt come from? Discuss the following information. Minerals from rocks gradually get washed out by rain-water. Some minerals are in the soil and they dissolve in the rain-water which makes its way to the rivers and finally end up in the sea. These minerals which collect in the sea give it a salty taste.

(Basic Science 1, Teacher's Handbook, Form 1/Class 7, p. 41)

In a Year 9 Class, the teacher was asking students to name the compound SO_3. After various attempts by students, the teacher finally told them that it was sulphur trioxide. One student interjected by saying "triangle", and for this, he was admonished by the teacher: "This is a science lesson - we are not doing maths". The student was probably trying to relate the "tri" in "trioxide" and "triangle", but this was not appreciated by the teacher.

Science lessons provide excellent opportunities for developing the language skills in students, but as the above examples show, such opportunities are lost if teachers keep their minds closed. Terms used in science become more meaningful if students are shown how they are used in different contexts.

Kulkarni (1988), in discussing these issues in the Indian context, makes an important point:

> While the importance of improving language skills for better science education is being appreciated, the role science can play in improving language skills is not fully realized. Science is ideally suited to present the correct usage of various conjunctions .... Modern trends highlight science at the expense of language. What is needed is a boot-strap approach using science to introduce pupils to higher language skills which in turn could be used for better science education.
>
> (Kulkarni, 1988, p. 166)

Discussion and Implications

The few examples I have given and the comments I have made illustrate the problems faced by our primary and secondary students trying to learn science in a second language. The problems were more acute among students who come from rural communities because they are exposed to English only when they are in the classroom; the rest of the time they communicate in their mother tongue.

When I discussed students' language difficulties with teachers, they usually began their comments by saying, "the type of students we have got here", and complained about students' lack of background and ability. Very few teachers were genuinely concerned about the language difficulties of students; perhaps they already had enough to do, teaching science to their students. Some shifted the responsibility to their colleagues teaching English.

I came across only one instance where a teacher had attempted to respond positively to students' difficulties. He did this in several ways. For a start, he related well to his students by constantly encouraging them even when their responses were not satisfactory. Students felt free to speak without fear of being humiliated. He also encouraged students to speak in their mother tongue (Hindi or Fijian) when they were doing activities or discussing questions in groups. After all, many students use their mother tongue while talking to their friends even inside the classroom. This teacher wanted to see if the experiment would help his students to understand the ideas better. He also gave the following advice to his students which I thought made sense in any context:

> Whenever you are going to define anything in [a] science lesson, it is better to give an example though the question doesn't say give an example...because if you are wrong in the definition, at least some marks will be given for your example. You will tell the examiner, this is what I am talking about - I might be wrong in my explanation but this is the example I am quoting.

Genuine and deliberate effort is needed both at the system level and at the classroom level to improve the language skills of students. Teachers need to be made aware of the importance of language in science education through regular workshops and courses. In our situation where for the majority of students the only sources of information are the teacher and the textbook, the quality of communication becomes even more important in promoting the understanding of science. Teachers and curriculum designers need to pay greater attention to how ideas are communicated to students and how ideas are received from students. Pupils need to be given more opportunities and encouragement to communicate their thinking both orally and in writing. After all this is one of the major stated aims of the Basic Science Curriculum:

> 5. [T]he course is designed to develop the ability to work with others, communicate and share ideas and to recognise and appreciate the points of view of other people.
>
> (Ministry of Education, Youth & Sport, 1976, pp. 1-2)

Teachers also need exposure to strategies that might be useful in realising this aim with their students.

References

Barnes, D. (1969). *Language, the learner and the school.* Harmondsworth: Penguin.

Bell, B., & Freyberg, P. (1985). Language in the science classroom. In R.Osborne & P.Freyberg, *Learning in science* (pp. 29-40). Auckland: Heinemann.

Gardner, P.L. (1974). Language difficulties of science students. *The Austra lian Science Teachers' Journal,* 20(1), 63-76.

Gardner, P.L. (1977). Logical connectives in science: a summary of findings. *Research in Science Education,* 7, 9-24.

Greenwood, J. (1990). Language in the science classroom. *Science Education Newsletter,* (89), 1-3.

Kulkarni, V.G. (1988). Role of Language in Science Education. In P.Fensham

(Ed.), *Development and dilemmas in science education* (pp. 150-167) London: The Falmer Press.

Ministry of Education, Youth & Sport. (1976). *Basic Science Forms 1-4. Intent - aims objectives examination.* Suva, Fiji: Author.

Muralidhar, S. (1989). *An exploratory study of a science curriculum in action: Basic Science in Fiji.* Unpublished PhD thesis, Monash University, Melbourne.

White, R.T. (1988). *Learning science.* Oxford: Basil Blackwell.