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COMPREHENSION LEVEL OF NON-TECHNICAL TERMS IN SCIENCE: ARE WE READY FOR SCIENCE IN ENGLISH

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Abstract: Most students find the learning of science not an easy task. These difficulties arise not only from the use of symbols to represent concepts, but also the language that must be mastered, in particular the technical and non-technical vocabulary. Students who learn science not in their first language face the problem of understanding both the scientific terminologies (technical terms) and regular explanation of the knowledge itself. Non-technical vocabulary refers to terms that have one or many meanings in everyday language but which have a precise and sometimes different meaning in a scientific context. Studies indicated that technical language of science posed a problem of familiarity, but students were seen to be able to cope reasonably well with this. Where a more acute problem lay, was in the use in science of normal, familiar language in a highly specific, often-changed and unfamiliar way. This paper will present the finding from a survey that aim at investigating form 4 students' comprehension of common non-technical terms used in science. Sample consisted of 91 students (form 4 students of different streams – arts, science and engineering) who were requested to respond to 50-item questionnaire. Facilities index were calculated for each item. Analysis of the result showed that these students do encounter some difficulties in understanding the meanings of the non-technical terms.

Abstrak: Kebanyakan pelajar mendapati bahawa mempelajari sains bukannya suatu tugas yang mudah. Kerumitan ini timbul bukan hanya dalam penggunaan simbol bagi mewakili konsep malahan bahasa yang perlu dikuasai terutamanya perbendaharaan kata berbentuk teknikal dan perbendaharaan kata bukan teknikal. Pelajar yang menggunakan bahasa bukan bahasa ibundanya untuk mempelajari ilmu sains menghadapi masalah memahami kedua-dua terminologi saintifik dan penjelasan biasa ilmu tersebut. Perbendaharaan kata bukan teknikal merujuk kepada terminologi yang bukan sahaja mempunyai satu atau beberapa maksud dalam bahasa harian tetapi juga satu maksud tepat dan kadangkala maksud yang berlainan dalam konteks saintifik. Kajian menunjukkan bahawa bahasa teknikal sains menimbulkan masalah yang lazim tetapi pelajar didapati dapat menanganinya dengan baik. Masalah yang lebih runcing adalah dalam penggunaan bahasa saintifik biasa yang amat spesifik, selalu bertukar dan gaya yang tidak lazim bagi pelajar. Kertas kerja ini akan membincangkan dapatan daripada soal selidik yang bertujuan menyiasat kefahaman pelajar-pelajar tingkatan 4 tentang terminologi-terminologi bukan teknikal biasa yang diguna dalam sains. Sampel terdiri daripada 91 pelajar (pelajar tingkatan 4 daripada aliran berlainan – sastera, sains dan kejuruteraan) yang dikehendaki menjawab soal selidik yang mengandungi 50 item. Indeks kesukaran dihitung bagi setiap item. Analisis terhadap keputusan respons menunjukkan bahawa

pelajar-pelajar ini menghadapi masalah untuk memahami maksud sesetengah terminologi bukan teknikal.

INTRODUCTION

In recent years, many researchers and practitioners have talked about integrating language and content when they refer to various ways in which foreign languages are used as a means of instruction. One of the reasons for the increasing interest among educators in developing content-based language instruction is the theory that language acquisition is based on input that is meaningful and understandable to the learner (Krashen, 1982). Language is acquired most effectively when it is learned for communication in meaningful and significant social situations. The academic content in the school curriculum can provide a meaningful basis for second language learning. The content provides the basis for understanding and acquiring new language structures and patterns. In addition, authentic classroom communication provides a purposeful and motivating context for learning the communicative functions of the new language. According to the Curriculum Development Center (2003), the use of English to teach and learn mathematics and science is geared towards enabling students to be able to collect information in science and technology which is written in English in order to keep pace with the latest development in science and technology. At the same time, students are expected to acquire proficiency in the academic language (also known as cognitive academic language proficiency, CALP) that is used as the medium of instruction.

Basic interpersonal communication skills (BICS) and CALP are two kinds of language proficiency hypothesized by Cummins (1981). BICS are language skills used in informal situations and CALP is the kind of language proficiency required to comprehend and use academic language in less contextually rich situations. BICS concept represents the language used by students when talking about everyday things in concrete situations, that is, situations in which the context provides cues that make understanding not totally dependent on verbal interaction alone (Cummins, 1992). The CALP concept is related to literacy skills in the first or second language. CALP is the type of language proficiency needed to read textbooks, to participate in dialogue and debate, and to provide written responses to tests (Cummins, 1980; Rosenthal, 1996). CALP enables students to learn in a context, which relies heavily on oral explanation of abstract or decontextualized ideas. This is often the context in which high school science is taught, with unfamiliar events or topics being described to students with little or no opportunity to negotiate shared meaning (Rosenthal, 1996).

According to Cummins (1982), CALP requires both higher levels of language and cognitive processes in order to develop the language proficiency needed for success and achievement in school. Students who have not yet developed their CALP could be, according to these researchers, at a disadvantage in learning science or other academic subject matter. Cummins (1981) contends that all children develop BICS and learn to communicate in their native or first language and that CALP reflects a combination of language proficiency and cognitive processes that determines a student's success in school. Cummins suggests that BICS are relatively easy to acquire, taking only one to two years, but CALP is much more difficult, taking five to seven years and necessitating direct teaching of the language in the academic context.

The learning of science requires students to master not only the use of symbols to represent concepts, but also the language, in particular the technical and non-technical vocabulary (Cassels & Johnstone, 1985). Non-technical vocabulary refers to terms that have one or many meanings in everyday language but which have a precise and sometimes different meaning in a scientific context (Cassels & Johnstone, 1985). Examples of non-technical terms include appropriate, component, consistent, estimate, negative and valid. These terms are amongst the 95 most difficult for secondary school students and their meaning in a scientific context is rarely well understood (Cassels & Johnstone, 1985). From the 95 words tested, the vast majority showed that their comprehension was more difficult for non-English native speakers in most contexts (Johnstone & Selepeng, 2001). Studies by Cassels and Johnstone (1983, 1985) indicated that technical language of science posed a problem of familiarity, but students were seen to be able to cope reasonably well with this. A more acute problem lies in the use in science of normal, familiar language in a highly specific, often-changed and unfamiliar way. Thus, discussion of the language involved is essential if a shared meaning is to be established.

Most students find the learning of science not an easy task. These difficulties arise not only from the use of symbols to represent concepts, but also the language that must be mastered, in particular the technical and non-technical vocabulary. Students who learn science not in their first language face the problem of understanding both the scientific terminologies (technical terms) and regular explanation of the knowledge itself.

Considerable advantage is to be gained, for both the teacher and the learner, in tackling these problems in the early stages. For the student, fluency in the related language can lead to a deeper understanding of scientific processes. The advantage for the teacher lies in the fact that once a shared meaning for symbols and terminology has been established and verified, more advanced or complex issues can be tackled with confidence.

METHODOLOGY

The aim of this descriptive case study was to assess students' comprehension of non-technical terms frequently used in the science and mathematics teaching. This study was done in 2004, a year after the implementation of teaching and learning of science and mathematics in English policy in schools. A prominent 'day school' in Kedah was chosen involving a total number of 91 form four students from three classes of different streams: arts (26 students), engineering (30 students) and science (35 students). Samples answered the survey instrument which consisted of two parts: part A and B. Part A consists of questions requiring personal information such as gender, type of class enrolled, nationality, language used at home and family background. Part B consists of 50 multiple choice questions (MCQ). Part B of this instrument was taken from the repeated survey done by Johnstone and Selepeng (2001). The 50 MCQ were divided into two categories: the ordinary everyday sentences (25 questions) and the scientific context sentences (25 questions). Both categories of questions used the 25 non-technical words (Table 1) that a science teacher would normally use assuming that students readily understand. These 25 words were arranged in scientific and ordinary everyday sentences making up the 50 sentences (MCQ).

Table 1. List of words used in the questionnaire

Words	
Abundant	Illustrate
Accumulate	Immerse
Characteristics	Impact
Complex	Interpret
Composition	Isolate
Constituent	Proportion
Crude	Rate
Diversity	Relative
Effect	Residue
Emit	Retard
Excess	Source
External	Substitute
Fundamental	

An example of one non-technical term used in the questionnaire is *abundant*. Item 8 is an example of sentence in scientific context using this word, *abundant:*

8. There was an abundant supply of gas to the reacting chemicals. This means that

   A. there was a shortage of the gas,
   B. the supply of gas was just enough for the reaction,

C. the gas was not suitable for the reaction, and
D. there was plenty of gas for the reacting chemicals.

Item 34 is an example of sentence in everyday usage (non-scientific context) also using the word *abundant:*

34. Apples were abundant last year. This means that

A. they were larger than normal,
B. there was a poor supply of them,
C. they were ready for picking earlier, and
D. there were plenty of them.

The sentences in scientific context were arranged at random with the sentences of non-scientific context. They were not juxtaposing one another nor were they arranged one after another. The reliability analysis of the items used revealed the alpha value of 0.89 indicating that the questions used were very reliable.

Statistical Package for Social Science (SPSS) program was used to analyze the data. The total scores and facility values (the fraction of students choosing the correct response) were computed.

RESULTS AND DISCUSSION

Figures 1, 2 and 3 show the performance of students in the arts, engineering and science classes, respectively. The mean score for form four arts students is only 20.2. Almost two-thirds (81%) of the students in this class scored less than 25 (answering less than 50% of the items correctly). Five students (19%) responded more than half of the items correctly and only two (8%) students answered 80% of the items correctly. The highest score was 45 and the lowest score was 11. These students did not attend the English class (English for Science and Technology, EST) that used science as its context unlike their counterparts; the science and the engineering students. This situation put the arts students at the disadvantage position as they received less exposure and less opportunity in CALP. Perhaps, this is one factor that contributed to the lower comprehension level by the arts students.

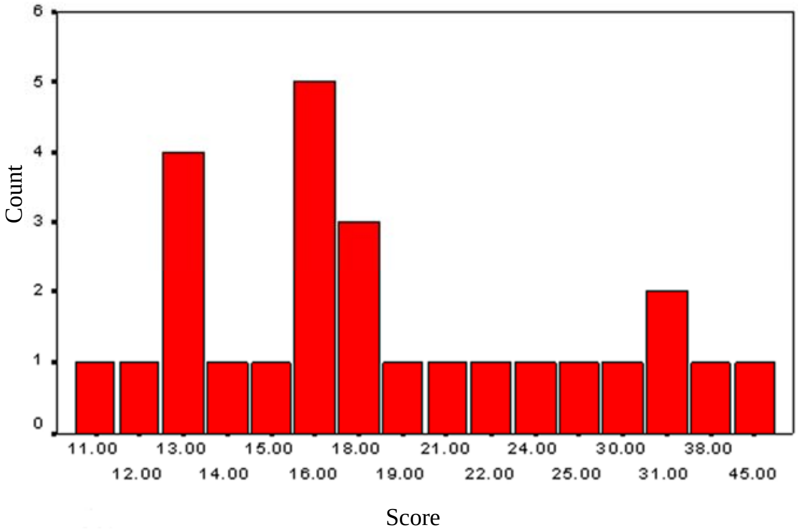

Figure 1. Score for form four arts students

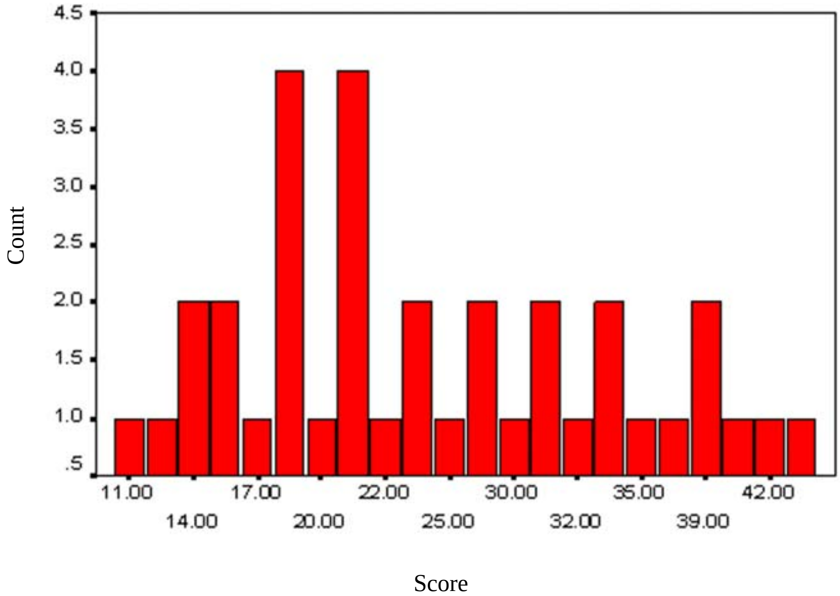

Figure 2. Score for form four science students

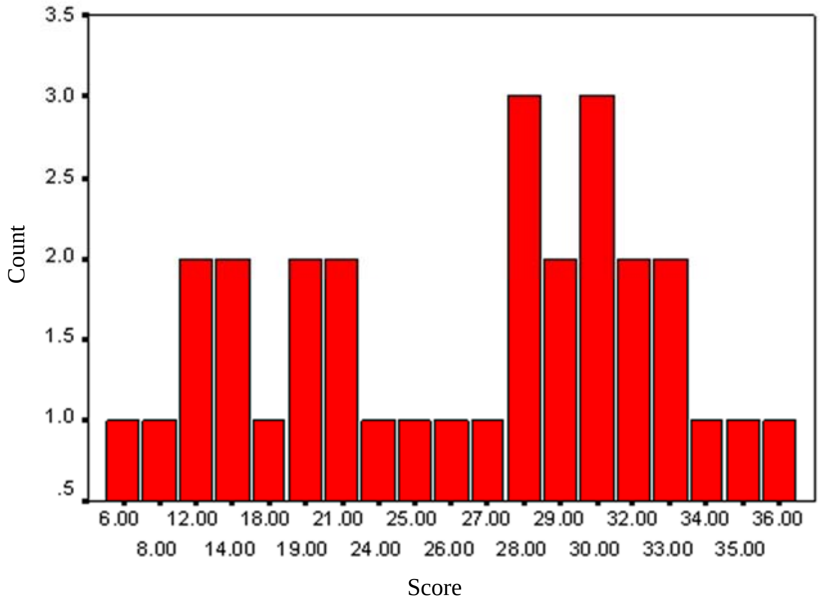

Figure 3. Score for form four engineering students

The form four science students performed better than students from the arts class on the average. The mean score was 25.9 as shown in Figure 2. There was a 5.7 marks advantage of science students over their counterparts from the arts class. Fifteen students (43%) answered more than half of the items correctly. The lowest score was 11 and the highest score was 43 as compared to the highest score performed by the arts student which was 45. As mentioned earlier, science students did receive more exposure and opportunity in CALP and the result was evident in their higher level of comprehension as compared to the arts students.

Figure 3 shows the performance of the students in the engineering class. Half of the class scored less than 25 but the other half of the class scored 30 or more. The average score is 24.4, only 1.5 less than the average score of the science class but 4.3 more than that of the arts class. The lowest score was 6 and the highest score was only 35. The facility values (FV = fraction of the class choosing the correct answer) of the words involved are shown in Table 2. Johnstone and Selepeng's study (2001) reported the mean for first language students was 0.75 and 0.56 for the second language students. The mean for the facility values found in our study was 0.45 which is lower than that of Johnstone and Selepeng's study. Comparing our students with the American students is perhaps unfair as the American students are surrounded with English language in everyday life whether or not they are first language students. The findings of our study also showed that students communicating in English at home did score higher than their

Table 2. Facility values for the science, arts and engineering classes

Words	Facility values		
	Arts class	Science class	Engineering class
Abundant	0.23	0.40	0.40
Accumulate	0.19	0.54	0.50
Characteristics	0.54	0.54	0.43
Complex	0.42	0.74	0.70
Composition	0.19	0.69	0.57
Constituent	0.31	0.34	0.20
Crude	0.19	0.23	0.17
Diversity	0.23	0.69	0.37
Effect	0.77	0.86	0.83
Emit	0.35	0.77	0.70
Excess	0.69	0.63	0.57
External	0.54	0.74	0.57
Fundamental	0.38	0.74	0.73
Illustrate	0.42	0.66	0.63
Immerse	0.27	0.31	0.30
Impact	0.15	0.31	0.20
Interpret	0.77	0.69	0.87
Isolate	0.12	0.63	0.33
Proportion	0.58	0.57	0.17
Rate	0.19	0.46	0.23
Relative	0.38	0.40	0.37
Residue	0.46	0.60	0.43
Retard	0.62	0.69	0.67
Source	0.58	0.77	0.60
Substitute	0.19	0.26	0.03

counterparts. For students scoring 25 or more from the science class, 14 students (82%) use English at home and only three do not. From the engineering class, 13 students (76%) communicate in English at home and four do not. The finding is a little different with the arts class, which only two students (28%) speak English at home while five others do not. Those two students were the ones scoring the highest two scores; 38 and 45, respectively. There seem to be a direct positive relationship between BICS (from students speaking English at home) and CALP (from the result of this test); the higher BICS, the higher CALP level was. This finding further supports suggestion by Cummins (1981) that BICS is much easier than CALP. Johnstone and Selepeng (2001) found that non-native English speakers had more difficulties understanding those words than native English speakers. Student who speaks English at home is in similar situation as those of native English speakers as both speaks English at home. The findings of this study (students speaking English at home showed a higher comprehension level than those students who do not speak English at home) corroborates Johnstone and Selepeng findings in 2001.

Analysis of the results showed that our students achieved higher FV for the words *effect, interpret, retard, source* and *excess*. A similar study (but not using the whole same set of words) by Zurida Ismail and Mohd Ali Samsuddin in 2003 on student-teachers majoring in science, also found that their samples achieved high FV (0.64) for the word effect. Comparing samples in this study (form four students in school) and those student-teachers on the comprehension level for the word effect, samples in this study did score much higher. This finding could raise a question of younger students with lower level of education understand better than older students with higher education. One possible explanation could be that the younger students are exposed to and surrounded by more use of English language.

These students still had some problems with the meaning of the words *rate, impact, substitute, crude, diversity, constituent, relative, immerse, abundant, isolate, accumulate, proportion, composition, residue* and *characteristics*. Table 3 shows the popular choice of responses (the non-correct answer) given by students. The study on teacher trainees in 2002 (Zurida Ismail & Mohd Ali Samsuddin, 2003) also found that the samples could not understand the word *isolate*.

The worst understood word by these students was *substitute* (Mean FV = 0.16). Instead of the correct meaning – to put in place of another – most popular choice of response or misconception was to bulk it up. The meaning of the word *crude* was mistakenly understood as safe instead of the intended meaning rough. The words that achieved mean FV of less than 0.30 were *substitute, crude, impact, constituent, immerse* and *rate* as stated in Table 3.

Table 3. Problematic words and their corresponding popular choice of response

Words	Popular choice of responses
Abundant	a poor supply
Accumulate	work out
Characteristics	numerical fact, similar property
Composition	length, width and height
Constituent	a piece of
Crude	safe
Diversity	matching colours
Immerse	wipe on to, splash on to
Impact	explosion, musical instrument
Isolate	operated on immediately
Proportion	stronger
Rate	noise
Relative	as, brother
Residue	savings
Substitute	bulk up

CONCLUSION

Result of this study showed that among the three streams (arts, science and engineering), the science class showed the highest comprehension level with a mean score of 25.9 followed by the engineering class with a mean of 24.4 and the arts class with 20.2. Perhaps, the contributing factor to this difference was the introduction of EST which was made compulsory to all science and engineering students but not to the students in the arts class. Level of comprehension of the non-technical terms commonly used in science teaching and learning can be improved when English is taught contextually. Suggestion could be made that when teachers teach the English language, usage of context in science and technology would help upgrade students' level of understanding the non-technical vocabularies. In general, these students still had problems in understanding some non-technical terms used in everyday communication. There is a need for our students to build up their vocabulary and to be familiar with the use of the words in several contexts. Students should be taught how to gauge the meanings of words on the context of use. Use of English should be extended outside of the classroom or science laboratories so that students have more chances of practicing communication in English in order for them to be familiar with the language and increase their vocabularies. The extended use of English could increase the BICS which will in turn help students in achieving the CALP needed to understand science. When science is taught to these students in English later on (at matriculation or college level), special considerations have to be made to the level of vocabulary used to aid them in understanding science, and the science concept itself must be taught in context with the students' experience or previous knowledge.

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