教育研究學報 1994，第九卷第一期，15-23
Educational Research Journal 1994, Vol. 9, No. 1, pp. 15-23

Words that Matter in Science: A Study of Hong Kong Students' Comprehension of Non-technical Words in Science

P.K. Tao

University of Hong Kong

This paper reports on an investigation into Hong Kong students' comprehension of 45 non-technical words commonly used in science. A total of 4644 Secondary 4, 5 and 6 students in a randomized sample of 46 schools, stratified by school type and area, participated in the study. The results showed that many students did not correctly comprehend a large proportion of the words, confused them with words that were phonetically or graphologically similar and even took them for their antonyms. Such poor performance raises doubts as to whether the majority of Hong Kong students have attained a 'threshold level' of competence in English to benefit from learning science in English.

本研究探討學生對 45 個科學科常用的非專有英文名詞的理解。研究採用以學校種類和地區爲分層的隨機樣本，受試者合共 4644 名來自 46 所中學的中四、中五及中六學生。結果顯示學生錯誤理解大部份非專有名詞，將同音和同形的名詞混淆，甚至與其相反詞混淆。一般學生對非專有名詞的低劣理解能力令人懷疑他們有否足夠的程度以英文來學習科學。

Basic language skills are a prerequisite for the study of any school subject. Students require such skills to make sense of teacher talk in the classroom, read and comprehend instructional materials, prepare written work, communicate with others, etc. Yet teachers often find that many students lack the necessary language skills to enable them to get on with learning the subject matter. The problem is particularly acute in science since the language used has a characteristic formal style, makes use of a specialized vocabulary and contains syntactic structures which are more complicated than those in other subjects (Richards, 1979). Students with poor language skills are prone to misinterpretation and confusion and their learning of science is severely hampered.

At the level of cognition, language is central to concept development. According to Vygotsky (1986), children build spontaneous concepts through their everyday interactions with people and the environment long before they can verbalise them. They have a non-conscious understanding of the concepts and it is only when they are able to express the concepts in words that their understanding is developed into a conscious form. To Vygotsky, concepts are not fully realized or understood until they are represented in words. He regards words as the means through which thought is formed and reified. A dynamic interdependent relationship exists between thought and words in that thought is developed through words and as thought develops new meanings are attached to the words and the process evolves as children's concepts develop. If the Vygotskian position is taken, students with poor language skills not only suffer from misinterpretation, but are also handicapped in their concept development.

There is a wealth of research on students' difficulties with the language in science. Studies have shown that students' understanding of science terms (e.g.,energy, molecule, organism) is erroneous and incomplete (Yager & Yager, 1985) and often differs from that of the teacher (Bell & Fryberg, 1985). But the problem goes beyond the technical words and also includes the vocabulary and usage of normal English in the science context. Gardner (1972) conducted a study for the Australian Science

The author is grateful to his wife for preparing most of the questions in the test papers; the Royal Society of Chemistry for permission to use 33 questions in Cassels and Johnstone's (1985) study; Cecilia Shek and Edmund Law for useful comments and suggestions on the first drafts of the test papers; the English teachers who helped with identifying the problematic words; and the schools and students who kindly consented to participate in the study.

Education Project on some 600 non-technical words used in science. For each word, a multiple choice question was prepared and the tests compiled were administered to large samples of students. From the results, Gardner compiled vocabulary lists of words accessible to students at different stages in secondary schools.

In the U.K., Cassels and Johnstone (1980, 1985) extended Gardner's work with a major modification: they tested each of the non-technical words in four contexts, viz. synonym, sentence, science and non-science. Different contexts were used to investigate if comprehension of the words was context-dependent. They found that for each word students' performance varied among the contexts and performance was satisfactory in all four contexts for only a few words. Cassels and Johnstone's study was later replicated by Marshall et al. (1990) in Pupua New Guinea where English was the offical language but not the first language of the students.

In the context of Hong Kong where over 90% of students attend Anglo-Chinese secondary schools and are supposed to learn science and other subjects in English rather than their mother-tongue, the language problem that students face can be enormous. While textbooks and examinations are in English, many teachers have resorted to teaching mainly in Cantonese, with frequent Chinese-English code-switching, to cope with students' generally low proficiency in English (Johnson & Lee, 1987). This is a peculiar language environment in which to learn science. It is unclear how students' language difficulties affect their science learning in such a situation, but it is worthwhile first finding out about the magnitude of the language problem.

Using Cassels and Johnstone's work (1985) as a basis, the present study investigates Hong Kong students' comprehension of English non-technical words commonly used in science. The study is significant in that it will provide an indicator of the magnitude of students' difficulty in learning science in English. Its findings will also inform both science and language teachers of the problematic words that require attention.

Method

The word list

Rather than using Cassels and Johnstone's (1985) word list directly, it was thought that an 'indigenous' list might be more relevant to the Hong Kong situation. Cheung and Lee (1986) compiled an English vocabulary from junior secondary textbooks but it was somewhat dated and not a vocabulary for the target senior secondary students. To compile a word list from the senior secondary science textbooks currently in use would be a big undertaking and it was decided to search for the words in the HKCEE Physics, Chemistry and Biology papers of the past five years (1988-92). Initially, a list of 118 non-technical words was produced and this was scrutinized by a panel of ten experienced English teachers. A final list of 45 words considered to be difficult to Secondary 4 students was compiled (Table 1). Not unexpectedly, 22 of the words in the list were the same as those in Cassels and Johnstone (1985) and 16 words coincided with those in Marshall et al. (1990). Of the 45 words, 10 were identified from the Biology papers, 19 from the Chemistry papers, 16 from the Physics papers. This exercise had paid off—the majority of the problematic words turned out to be those that have been identified locally, as discussed under 'Results and Discussion'.

Table 1
The word list

account	device*†	interpret*†
achieve	effect*†	liberate*
action	emit*	maintain
appropriate*†	essential*	negligible*
associate	establish	persist
assume	estimate*	random*†
characteristic*†	evacuate*†	relative*
component*†	evolve	release
composition*†	excess*†	resume
conserve	exert*†	sequence*†
contribute*†	generate*†	subsequent
deliver	illustrate*†	transform
denote	initial*†	uniform
derive	instant	variation
determine	instantaneous	vigorous

*Words in common with Cassels & Johnstone (1985)
†Words in common with Marshall (1990)

The test papers

Multiple choice questions were prepared to test students' comprehension of the words in the list. For each word, questions were set in four contexts, viz. synonym, sentence, science and non-science. Examples of the contexts for one of the words are given in Table 2.

Most of the questions in the synonym, sentence and non-science contexts were prepared by an experienced English teacher and those in the science context by the researcher himself. As far as possible, questions in science context used the wordings in the

Table 2
The four contexts for the word 'instant' (% responses given within brackets and key marked with)*

1. *Synonym context*
   'Instant' can mean
   A. happening. (12%)
   B. incident. (12%)
   C. moment. (64%)*
   D. instinct. (12%)

2. *Sentence context*
   Which sentence uses the word 'instant' correctly?
   A. With more instant, we can do the work better. (16%)
   B. Tommy put his homework aside the instant his mother left home. (26%)*
   C. Lucy seems to have an instant for choosing the correct answer. (33%)
   D. May I keep you an instant to answer a few questions? (25%)

3. *Science context*
   The diagram shows the wave at two different instants. This means the wave is drawn
   A. at two different moments. (44%)*
   B. at two different places. (14%)
   C. using two different methods. (16%)
   D. in two different patterns. (26%)

4. *Non-science context*
   Wait here, I shall be back in an instant. This means I shall be back
   A. in a second. (52%)*
   B. after some time. (32%)
   C. in an hour or two. (6%)
   D. at your request. (10%)

examination papers verbatim. Out of a total of 180 questions for the 45 words, 33 questions (for 17 words) from Cassels and Johnstone's study were used, 8 with minor changes to suit the Hong Kong context. This was to expedite the preparation of the questions, which was a difficult and time-consuming exercise, so that testing could be conducted in schools as scheduled.

From the questions prepared, four parallel test papers were compiled, each paper testing the comprehension of the 45 words in *one* of the contexts. Five control questions, from Cassels and Johnstone's study, were added to each paper. These questions were kept in one context only and tested the comprehension of five words: 'percentage', 'excite', 'capable', 'repel' and 'average'.

All the questions were scrutinised for accuracy, suitability and validity by two English language teacher educators. The draft test papers were trialled in two schools. In the light of the comments and suggestions and the item statistics of the trial test, some minor changes were made to the wordings of several questions.

Sampling procedure

Forty-six schools, selected at random according to a 12% proportional stratification by school type (government, grant and aided schools) and area (19 areas in total), were invited to participate in the study. Due to non-response or refusal, a second round of invitation had to be sent. The two rounds of invitation resulted in 37 schools agreeing to take part in the study. As the Secondary 5 classes were about to take leave for the HKCE Examination, the researcher had to secure the remaining 9 schools in the 'missing' strata using his personal contacts. It should be noted that Cassels and Johnstone (1985) used a volunteered sample and Marshall (1990) presumably used a convenience or volunteered sample since no sampling information was given.

Each of the 46 participating schools was randomly assigned one of four test papers. In each school, the test was administered to one science class each of Secondary 4, 5 and 6. The testing took place in March/April, 1993. Information on the sample is given in Table 3.

Table 3
The sample

School type	Total No.	No. in sample	No. of sampled students
Goverment	43	6	630 (14%)
Grant	22	3	285 (6%)
Aided	304	37	3729 (80%)
	369	46	4644(100%)
Grade			
S4			1844 (40%)
S5			1579 (34%)
S6			1221 (26%)
			4644(100%)

Data analysis

The following statistical analyses were performed:

1. For each of the four papers Cronbach's alpha and split-half reliability coefficient.
2. Test of significant difference between the percentages of correct responses to the five control questions between the four papers.
3. For each of the 200 questions in the four test papers
   (a) percentage of responses to each option;
   (b) item statistics (facilities and discrimination indices).

4. For each word in the papers
   (a) overall performance (percentage of correct responses) in each context;
   (b) overall performance in each grade;
   (c) performance in each context in each grade.

Performance is taken to be 'satisfactory' if the percentage of correct responses is equal or higher than 70%.

Results and Discussion

Reliability coefficients

The four papers were found to have very high internal consistency: the Cronbach's alphas were 0.89, 0.91, 0.89 and 0.87 and the split-half reliability coefficients were 0.78, 0.78, 0.78 and 0.75 respectively.

Item statistics

The mean facility of the 180 questions in the four test papers was 54.5% (standard deviation 17.6%) and the mean discriminating index was 0.40 (standard deviation 0.13). The tests in this study were criterion-referenced rather than norm-referenced. As such, questions with low discrimination index should not be dismissed as poor questions without closely examining the wordings of the questions and the response patterns; they could well be questions on problematic words which require attention. The results showed that the discrimination indices of 144 questions (80%) well exceeded 0.30, 23 questions (12.8%) were between 0.20 and 0.29 and 13 questions (7.2%) were less than 0.20. The 13 non-discriminant questions all had low facilities. This overall pattern suggests that the multiple choice questions in the papers were generally well set.

The control questions

The first five questions were common to each paper and used as a control to check whether the allocation of the four papers to the participating schools were random. It was found that there was no significant differences between the groups of students who did the four papers.

The five control questions were identical with those used in Cassels and Johnstone (1985) and Marshall et al. (1990) and so comparison can be made with them, but insufficient information was available for testing significant difference between the three studies. However, it can be seen from Table 4 that Hong Kong students' performance on the five words was substantially poorer than students in Cassels and Johnstone's and Marshall's samples. The overall performance on four of the five words was unsatisfactory (i.e. correct responses lower than 70%). Even for Secondary 6 students, performance on 'percentage', 'excite' and 'repel' was unsatisfactory. Closer examination of student responses showed that many students confused 'percentage' with 'average', 'capable' with 'working hard' and many had difficulties with the use of 'excite' and 'repel' in the sentence context. This is an alarming result as it was thought that these words were rather simple and such poor result was not anticipated.

Table 4
Percentage of correct responses to the five control questions: comparison with Cassels & Johnstone (1985) and Marshall et al. (1990)

Question/word	Present study				Cassel & Johnstone	Marshall et al.†
	S4	S5	S6	Overall		
1 percentage	41	40	57	45	93	92
2 excite	41	47	63	49	93	84
3 capable	54	61	81	64	95	82
4 repel	40	47	54	46	81	69
5 average	71	75	88	77	97	86

* mean percentages extracted from Cassels & Johnstone (1985) for the equivalent S4 to S6 students
† mean percentages for Grade 7 to 12 and University Year 1 students

Performance across grades

Table 5 gives the percentages of correct responses to the questions by grade and by context. As would be expected, performance improved with the grade level. This was true for the overall performance (increase from 45% in S4 to 53% in S5 and to 71% in S6) as well as for performance on individual words. The improvement in performance was generally more marked from S5 to S6 than from S4 to S5. This is not unexpected since entry to S6 is selective, based on the HKCEE results.

Performance across contexts

It can be seen from Table 5 that none of the 45 words had satisfactory performance in all four contexts. Performance was satisfactory in three contexts for four words ('effect', 'excess', 'initial', 'maintain'), and in two contexts for four words ('essential', 'liberate', 'random', 'uniform'). Of the remainder, 19 words (42%) had satisfactory performance in one context and 19 words (40%) were unsatisfactory in all four contexts. This clearly indicates that the Hong Kong students in the sample had very poor comprehension of the non-technical words tested.

Table 5
Percentage correct by context and by grade

	Context				Grade			Overall
	Synonym	Sentence	Science	Non-science	S4	S5	S6	
account	48	50	44	76	43	55	74	55
achieve	40	49	47	58	36	42	52	48
action	15	53	58	38	41	45	65	42
appropriate	69	27	58	71	47	56	74	57
associate	71	55	52	45	44	54	76	56
assume	36	51	68	66	50	50	68	55
characteristic	56	60	65	84	57	67	78	66
component	66	53	58	73	53	59	80	63
composition	63	72	66	63	57	64	80	66
conserve	34	43	60	48	36	45	62	46
contribute	37	35	45	73	38	44	66	47
deliver	45	46	29	69	39	44	64	47
denote	57	40	56	66	45	55	70	55
derive	34	27	39	70	37	37	56	42
determine	58	26	64	79	50	55	68	56
device	62	52	46	69	41	59	80	57
effect	21	74	74	74	54	58	71	60
emit	60	67	80	68	53	69	90	68
essential	63	68	83	86	66	75	89	75
establish	77	39	56	44	48	53	67	54
estimate	54	22	39	53	33	40	61	42
evacuate	30	23	43	28	27	27	42	31
evolve	25	38	80	39	37	49	56	46
excess	91	64	73	80	67	78	92	77
exert	26	41	57	42	33	36	60	41
generate	52	41	67	67	42	55	80	56
illustrate	20	53	51	44	35	51	57	43
initial	86	64	79	82	69	78	92	78
instant	63	26	44	52	34	46	66	47
instantaneous	56	40	58	31	36	46	63	46
interpret	44	28	56	60	41	44	60	47
liberate	67	36	74	73	51	62	82	63
maintain	64	71	77	78	63	70	90	73
negligible	60	61	81	44	46	61	87	62
persist	28	24	31	25	20	27	38	27
random	68	74	63	74	56	71	89	70
relative	63	30	52	62	43	46	73	52
release	44	57	88	74	59	61	79	65
resume	25	28	53	77	40	45	56	46
sequence	72	48	49	56	43	57	76	56
subsequent	58	27	32	69	40	47	60	47
transform	43	29	75	32	38	42	57	44
uniform	58	32	86	86	60	63	77	65
variation	57	42	32	82	44	54	69	54
vigorous	78	58	68	55	55	63	82	65
Mean	52	45	59	62	45	53	71	55
Std dev	18	15	16	17	11	12	13	11
Maximum	91	74	88	86	69	78	92	78
Minimum	15	22	29	25	20	27	38	27

The overall performance of the non-science context was better than that of the science context ($p < 0.01$). In addition, for 24 words, performance in the non-science context was better than in the science context, for 3 words performance was the same and for 18 words performance was poorer. Also, for 16 words the best performance was found in the non-science context and for 11 words in the science context. This suggests that the Hong Kong students in the sample found many of the words easier to comprehend in the non-science context than in the science context. This result is contrary to that obtained by Marshall et al. (1990) for Papua New Guinea students.

Among the four contexts, overall performance was worst in the sentence context and poor in the synonym context. It is understandable that weak responses occur in the synonym since there is no context from which a meaning can be deduced. However, the poor performance in the sentence context showed that the Hong Kong students in the sample had problems not only with comprehending the meaning of the words but also with using them correctly. The correct usage of a word is more demanding than its comprehension. Hong Kong students often relate English words to the meaning of the Chinese translation but are unable to use them correctly in sentences. This point can be illustrated using the following question on 'resume' (percentage of responses to each option is given in brackets and the key is marked with a *)

Which sentence uses the word 'resume' correctly?

A. It is not right to resume that this man is a thief. (23%)
B. My driving license will soon expire. I must resume it. (27%)
C. Father will resume his work after the holiday. (28%) *
D. The builders will resume the building to its former condition. (22%)

The word 'resume' means 'begin again after a stop' but many students confused it with 'assume', 'renew' and 'restore'. The Chinese translation of 'resume' conveys, to some extent, the meaning of 'renew' and 'restore', and so options B and D would appear to be plausible.

Performance on selected words

By way of illustration, the performance on four locally identified words are discussed in detail. Figure 1 shows the performance on the four words by grade and by context.

'Derive'. The overall performance on 'derive' was very poor (synonym 34%; sentence 27%; science 39%; non-science 70%), with only the non-science context barely reaching the satisfactory level. Figure 1 shows that performance was only satisfactory for S6 students in the non-science context.

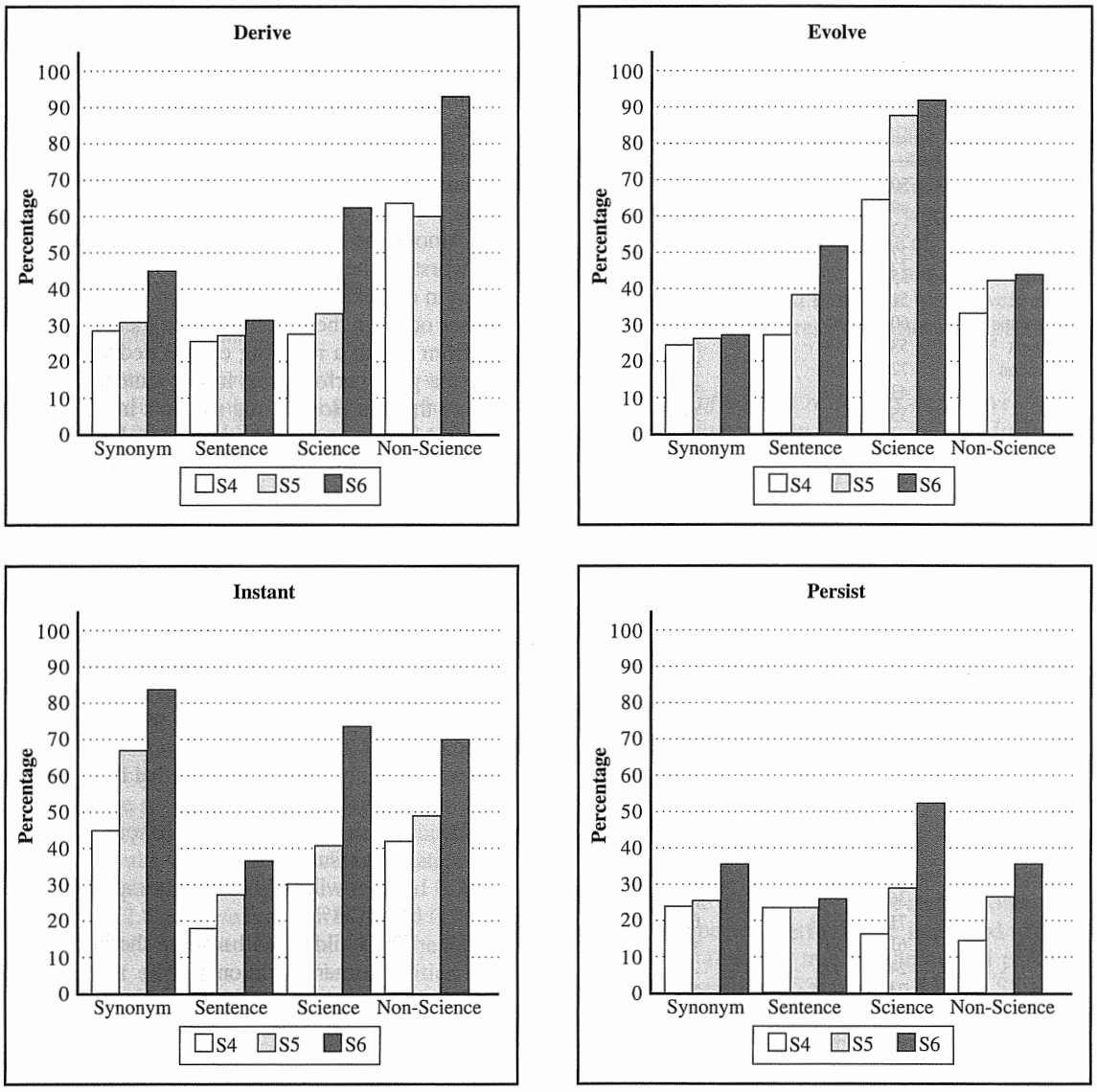

Figure 1 *Student performance in four contexts.*

The percentage of correct responses to the synonym context were: device 30%, divide 17%, develop 34%*, decide 19% where the major confusion was with 'device'. The confusion exhibited by the sentence context answers were with 'deprive', 'devise' and 'arrive', as can be seen from the following:

A. The government should not derive its people of the freedom of speech. (22%)
B. I am beginning to derive great pleasure from reading. (28%)*
C. They want to derive a special tool to do the work (28%)
D. We must derive at a decision soon. (22%)

In the science context, many students took 'The scientific principle is derived from the experiment' to mean that the principle is 'confirmed by the experiment' (17%) or 'proved by the experiment' (34%), rather than 'developed from the experiment' (39%). In the non-science context, most students (70%) correctly took 'Some English words are derived from Latin' to mean that they 'come from Latin'.

'Evolve'. The overall performance was poor in all except the science context (80%). Figure 1 shows that performance was satisfactory in the science context for only S5 and S6 students. This could be

because most students met this word in the science context only.

The synonym context proved to be the most difficult question with almost equal percentages of correct responses to each option: occur 33%, resolve 23%, develop 26%*, revolve 18%. The responses to the sentence context showed that many students confused 'evolve' with 'revolt', 'revolve' and 'resolve' as shown by the following:

A. The soldiers evolved against their government. (15%)
B. The earth evolve round the sun. (20%)
C. We are unable to evolve this problem. (27%)
D. The theory has evolved over the past century. (38%)*

In the non-science context, many students took 'a new plan has evolved' to mean that the new plan has been 'immediately worked out (22%), cancelled (19%), or decided upon (20%), rather than gradually developed (39%)*

'Instant'. The questions on 'instant' are given in Table 1. The overall performance was unsatisfactory on all contexts. Figure 1 show that performance was satisfactory only for S6 students, in three out of four contexts.

In the sentence context, the major confusion was with 'instinct' (33%). However, in terms of the meaning of the word, especially the Chinese translation, options A and D seem plausible, but they were incorrect or improper usage of the word 'instant'.

In the science context many students took 'the wave at two different instants' to mean 'two different wave patterns' (26%) rather than 'the wave at two different moments' (44%)*. The expression 'at different instants' is often used in physics for time-varying quantities and failure to comprehend the meaning would inhibit understanding of the relevant concepts.

In the non-science context many students took 'be back in an instant' to mean 'be back after some time' (32%), which is quite the opposite to 'be back in a second' (52%).

'Persist'.The overall performance was unsatisfactory for all contexts and all grades. Figure 1 shows that the best performance was in the science context for S6 students (53%), but this was still unsatisfactory.

In the synonym context, the percentages of responses to the different options are: resist 17%; continue 28%*; permit 28%; refuse 27%.

Confusions exhibited by the sentence context responses were between 'persist' and 'insist' and 'resist' as shown by the following:

A. Mother persists me to join the Boy Scout. (32%)
B. Heavy rain is likely to persist in the next few days. (25%)*
C. I put on a thick coat to persist the cold wind. (28%)
D. We should all persist good habits. (15%)

In the science context, many students took 'the emulsion will persist when left to stand' to mean the emulsion will 'disappear' (20%), 'change to some other thing (17%), and 'be formed' (31%). The correct response, 'will not disappear' drew only 32%.

In the non-science context, many students took 'Mary persists in wearing that hat' to mean Mary 'refuses to wear that hat' (35%), 'likes to wear that hat' (26%) and 'pretends that she is wearing that hat' (13%).

Words requiring attention

Words with unsatisfactory performance (i.e. percentage of correct responses lower than 70%) in at least three out of the four contexts are designated 'problematic' words. These words are listed in Table 6 by grade and denoted by Xs. It can be seen that only three words ('essential', 'initial' and 'uniform') do not require attention in all three grades. The number of words requiring attention are 42 (93%) in S4, 37 (82%) in S5 and 13 (29%) in S6. In Marshall et al. (1990), the number of words requiring attention in the corresponding grades are 25, 8 and 5. Although direct comparison is not possible since the word list and questions are not all the same, this result again points to the poor performance of the Hong Kong students in the sample.

Confused words

The results showed that students often confused the words tested with words which were graphologically or phonetically similar: for example 'instinct' with 'instant'; 'insist' and resist' with 'persist'; 'receive' with 'achieve'; 'assure'with 'assume'; 'deprive' with 'derive'; 'advice' with 'device'; 'assert' with 'exert', 'interrupt' with interpret'; 'distinguish' with 'determine'; 'resolve' with 'evolve'; 'generalise' with 'generate'; 'evaluate' with 'evacuate'; 'transmit' with 'transform'; 'reserve' with 'conserve'. In some cases, students even confused the words with their antonyms: for example 'fill' with 'evacuate'; 'disappear' with 'persist'; 'take in' with 'emit'. It is not possible to ascertain that such meanings of the words were strongly held by the students; when

Table 6
Words requiring special attention

	Grade		
	S4	S5	S6
account	X	X	
achieve	X	X	X
action	X	X	X
appropriate	X	X	
associate	X	X	
assume	X	X	
characteristic	X	X	
component	X	X	
composition	X	X	
conserve	X	X	
contribute	X	X	X
deliver	X	X	X
denote	X	X	
derive	X	X	X
determine	X	X	
device	X	X	
effect	X		
emit	X		
essential			
establish	X	X	
estimate	X	X	
evacuate	X	X	X
evolve	X	X	X
excess	X		
exert	X	X	X
generate	X	X	
illustrate	X	X	X
initial			
instant	X	X	
instantaneous	X	X	
interpret	X	X	
liberate	X		
maintain	X	X	
negligible	X	X	
persist	X	X	X
random	X		
relative	X	X	
release	X	X	
resume	X	X	X
sequence	X	X	
subsequent	X	X	X
transform	X	X	X
uniform			
variation	X	X	
vigorous	X	X	
No. of words	42	37	13

faced with total incomprehension, students might simply select the option that appeared to be similar. But what is certain is that students' comprehension of the words tested was very poor.

Conclusion

Hong Kong students in the sample generally performed poorly in the tests, worse than students in the studies by Cassels and Johnstone (1985) and Marshall et al (1990). They failed to comprehend a large proportion of the non-technical words tested, confused them with words that were phonetically or graphologically similar and in some cases even took them as their antonyms. Hong Kong students also had problems with the correct usage of the words in sentences. This may have to do with the dominant use of Cantonese in the classroom so that students get very little practice in the usage of the words in English.

Students' language problem can be alleviated, to some extent, if science teachers are made more aware of students' difficulties in comprehending the non-technical words in science. Teachers usually take time to explain the science terms when they first arise, but seldom pay much attention to the non-technical words. In the majority of classrooms, teaching is mainly conducted in Cantonese and students have very little chance of encountering the non-technical words, except when they read the textbook themselves. Teachers can, therefore, help by drawing students' attention to the non-technical words, testing and ascertaining their comprehension of these words, and providing them with practice in the usage. The present study provides information on a selection of the problematic non-technical words at different grade levels which should be useful for this purpose.

Students' poor performance in the tests suggests that many students have not attained a 'threshold level' of competence in English to enable them to effectively learn science (and presumably other subjects) in English. However, the medium of instruction is a very controversial and complex issue and the choice of language is determined more by social, economic and political factors than findings of educational research. Arguably, two diametrically opposite courses of action may be taken to address the language problem. First, students diagnosed to have low proficiency in English may be channelled into Chinese-medium education, as recommended by the Education Commission Report No. 4, (Education Commission, 1990) but this will surely be met with strong opposition from parents and result in social segregation between students in Chinese- and English-medium schools or classes within the same school. Alternatively, steps may be taken to improve the teaching of English in schools and this will require effective language planning, systematic research and massive investment of resources. If the latter course of action is taken, findings of the present research may be used to inform teachers of the sort of difficulties students

face in comprehending the non-technical words in science at different grade levels.

References

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

Cassels, J.R.T., & Johnstone, A.H. (1980). *Understanding of non-technical words in science.* London: Royal Society of Chemistry.

Cassels, J.R.T., & Johnstone, A.H. (1985). *Words that matter in science.* London: Royal Society of Chemistry.

Cheung, Y.S., & Lee, P.L.M. (1986). *A study of English vocabulary in junior secondary* textbooks in Hong Kong. Hong Kong: Government Printer.

Education Commission (1990). *Education Commission Report No.4.* Hong Kong: Government Printer.

Gardner, P.L. (1972). *Words in science: An investigation of non-technical vocabulary difficulties amongst Form I, II, III and IV science students in Victoria.* Melbourne: Australian Science Education Project.

Johnson, R.K., & Lee, P.L.M. (1987). Modes of instruction: Teaching strategies and student responses. In R. Lord & H.N.L. Cheng (Eds.), *Language education in Hong Kong* (pp.99-121). Hong Kong: The Chinese University Press.

Marshall, S., Gilmour, M., & Lewis, D. (1990). *Understanding and misunderstanding in science: A study of Papua New Guinean students' comprehension of non-technical words used in science.* Lae: University of Technology.

Richards, J. (1979). *Classroom language: What sort?* London: Allen & Unwin.

Vygotsky, L. (1986). *Thought and language* (A. Kozulin, Trans.). Cambridge, MA: M.I.T. Press.

Yager, R.E., & Yager, S.O. (1985). The effect of schooling upon understanding of selected science terms. *Journal of Research in Science Teaching, 22,* 359-364.