The semi-technical vocabulary selected as test items in the MCQSs of both the pilot and main study was based on the correct responses subjects gave in the DWLGE 1 and DWLGE 3 respectively. According to the results from the DWLGE 3, the three items, *index*, *menu* and *field*, which were explained correctly by all 60 subjects in the pilot study, were not correctly explained by all 365 subjects in the main study. Therefore, three other semi-technical items, *copy*, *update* and *page*, which were correctly explained by all 365 subjects in non-CS contexts, were used as test items in the MCQS of the main study (see Appendix 8).

In order to establish whether a prototype corpus-based subject-specific glossary of semi-technical vocabulary is a more efficient consulting tool for students than a general learner's dictionary, subjects were given four GLDs, viz. *COBUILD 1*, *LDOCE 2*, *OALD 4* and *OALECD 4*, to consult during the pilot study. Subjects took longer to finish the HOCTs with the GLDs. The main reason for this appears to be that some of them tried to search for every word in all four GLDs. To avoid the same situation happening again, each subject was therefore assigned only one GLD for consultation in the main study.

MCQS with/without TAT and RI

To examine the hypothesis that unexplained semi-technical vocabulary adversely affects students' understanding of CS texts, 365 subjects were asked to write the meanings of the 40 words in DWLGE 3 (see Appendix 6), which were then returned to me with written feedback. Twenty-one semi-technical vocabulary items were selected to construct the MCQS which was then given to the 365 subjects to complete. Among them, 60 subjects completed the MCQS with the TAT and attended the RIs. The results obtained from the DWLGE 3 and the MCQS, with or without the thinking-aloud technique, indicate that the semi-technical vocabulary items under investigation create problems in understanding.

In Figure 2 below, the dotted line represents the scores of the DWLGEs while the solid line represents these of the MCQS. The mean of the correct scores obtained by the 365 subjects is 100, but when the same 21 vocabulary items appeared in the CS context, the mean is 25.3 (SD = 10.96) (see Figure 3). Data from both the thinking-aloud protocol and the RIs agree with the statistical data. Subjects generally felt that it was more difficult to grasp the meaning of a general word in a CS context. Although most of the subjects claimed that they knew that the semi-

technical vocabulary items carried metaphorical senses, they were unable to select the correct answers in the survey questions.

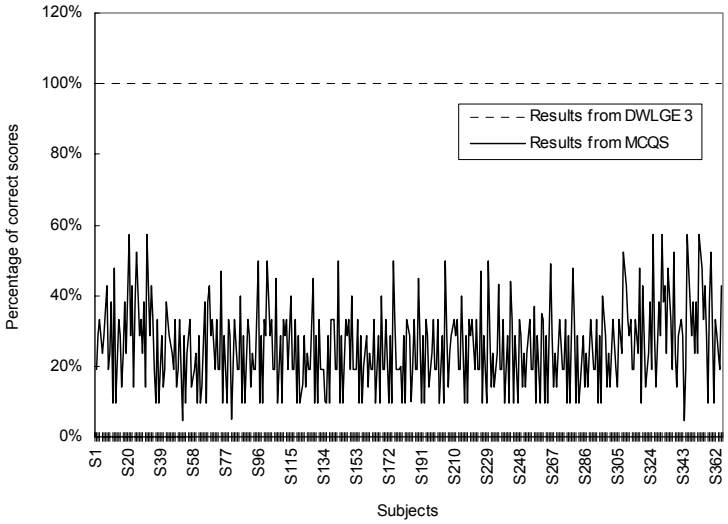

Figure 2: Comparison of the DWLGE 3 and the MCQS, with and without the TAT and the RI.

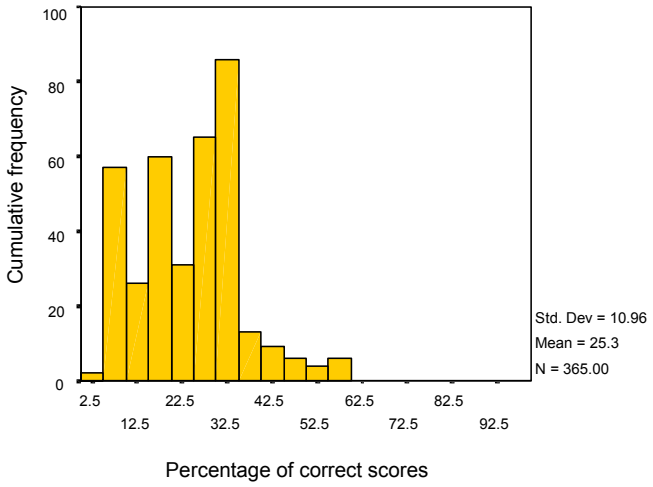

Figure 3: Results from the MCQS with and without the TAT and the RI.

HOCTs with/without TAT and RI

To examine the hypothesis that a prototype corpus-based subject-specific glossary of semi-technical vocabulary is a more efficient consulting tool for a first-year student at UST than a GLD, in terms of both ease of use and the time required for consultation, 80 subjects were given the DWLGE 4 to complete. Written, rather than spoken, feedback, was received. The same 21 vocabulary items were selected to form the HOCTs, which 40 subjects used the TAT to complete and later attended the RIs. The remaining 40 subjects completed the tasks without involving either technique.

DWLGE 4 was used to interview the 80 subjects to identify vocabulary items whose meanings the subjects knew in a general English context. The same 21 vocabulary items explained correctly by subjects in both DWLGE 2 and 4 were chosen to form the HOCTs. Subjects were asked to attempt the same HOCTs twice.

Instead of, as in the pilot study, being given four GLDs, subjects were assigned only one GLD to help them to complete the tasks. Half the cohort used the TAT and attended the RIs; while the other half completed the tasks without either technique. After a week, the same 80 subjects were given the EGSV to help them to work on the HOCTs.

The data obtained are consistent with the results from the MCQS. In Figure 4, the upper line, representing the scores the 80 subjects obtained from the DWLGE 4 when they were asked to write down the general meanings of the 21 vocabulary items, shows that the mean of the correct scores obtained by all subjects is 100. However, the mean of the correct scores obtained by the same subjects in the HOCT as shown in Figure 5 is only 22.8 (SD = 13.90). The difference between the two means again confirms that semi-technical vocabulary items create problems for students wishing to understand computer program manuals such as *Running Word 6 for Windows*. Such problems may hamper subjects in using the word-processing programs effectively.

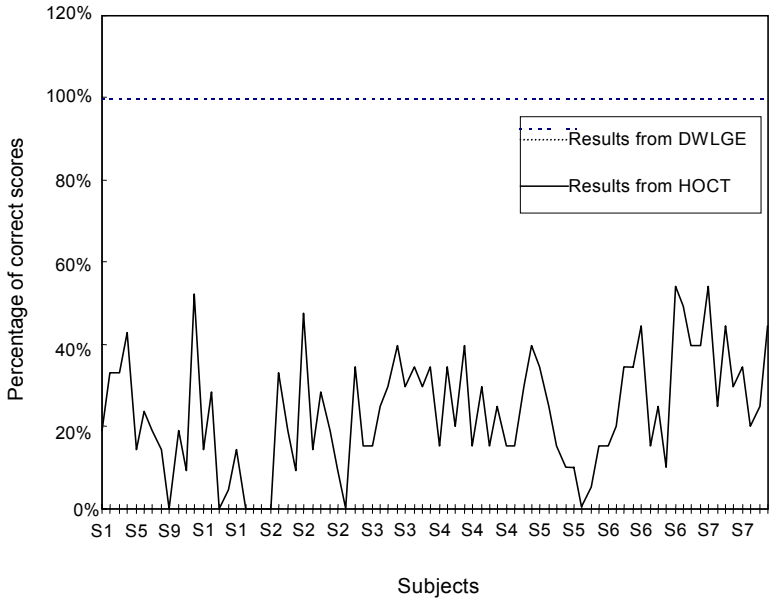

Figure 4: Comparison of the DWLGE and the HOCT with and without the TAT and the RI.

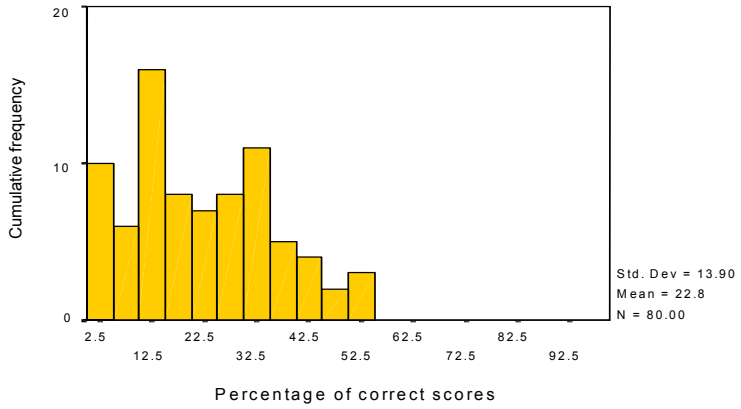

Figure 5: Results from the HOCT with and without the TAT and the RI.

Comparison of results between the GLDs and the EGSV

Eighty subjects were asked to work on the HOCTs twice, 40 of them using the TAT and attending the RI. In the first attempt, four different GLDs were evenly distributed to the 80 subjects as consulting tools. In the second attempt, subjects were given the EGSV to consult. As indicated in the ANOVA analysis in Figure 6 below, the results of the linear model are significant. No matter which GLD was consulted, or whether the TAT and the RI were involved, all subjects needed more time to complete the HOCT than when they used the EGSV as the reference tool (see Table 5).

Table 7: Estimated marginal means of time used in consulting with GLDs and the EGSV.

Estimated marginal means of time used		
consulting	**without TAT or RI**	**with TAT and RI**
COBUILD 1	60 mins	71 mins
LDOCE 2	68 mins	70 mins
OALD 4	49 mins	57 mins
OALECD 4	51 mins	56 mins
EGSV	**40 mins**	**44 mins**

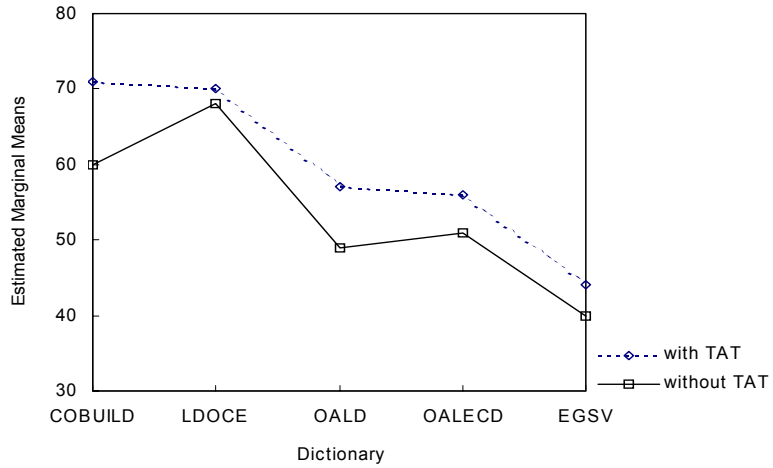

Figure 6: Estimated marginal means of time used (in minutes).

Both the shaded boxes and the white boxes in the plots of the ANOVA analysis, illustrated in Figure 7 below, again show that all 80 subjects used more time to finish the HOCT using the GLDs than when they consulted the EGSV to complete the task (see Table 8).

Table 8: Time spent in completing the HOCTs.

Time spent in completing the HOCT		
consulting	**without TAT nor RI**	**with TAT and RI**
COBUILD1	47–70 mins	61–80 mins
LDOCE 2	58–78 mins	62–80 mins
OALD 4	41–53 mins	50–59 mins
OALECD 4	42–51 mins	43–59 mins
EGSV	**37–40 mins**	**39–43 mins**

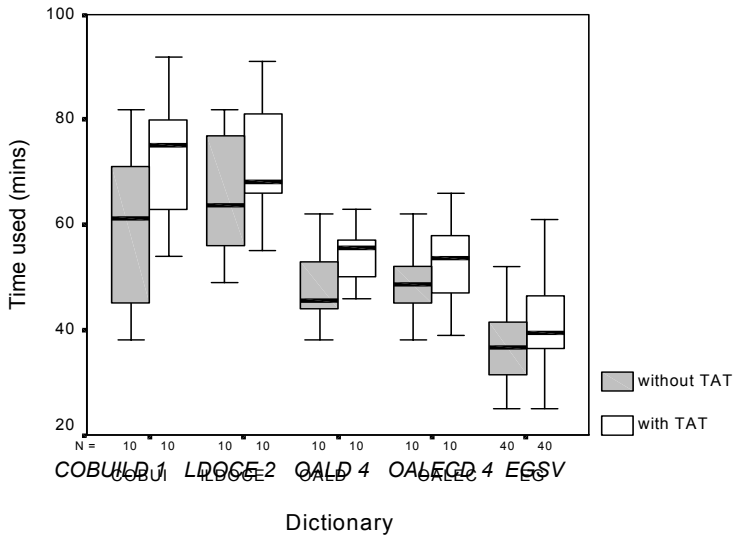

Figure 7: Comparison of the time used (in minutes) in completing the HOCTs when the GLDs and the EGSV were used.

Data gathered from the thinking-aloud protocols and the retrospective interviews confirm these findings. The 80 subjects who participated in the two-phase HOCT tests unanimously indicated that they found the EGSV

easier to use, quicker for finding the information they wanted and, therefore, more useful than GLDs in helping them to complete the HOCTs.

The two sets of scores obtained from the 80 subjects were analysed to see whether the EGSV is more efficient as a consulting tool than the GLD in terms of ease of use: see Figures 8 and 9 below.

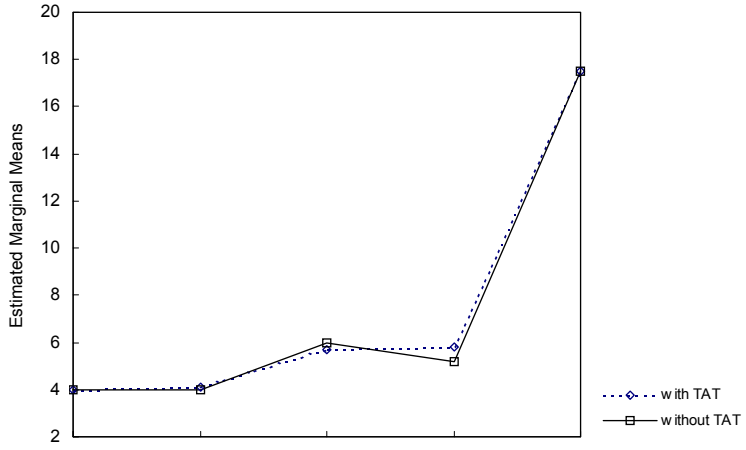

Figure 8: Estimated marginal means of correct answers.

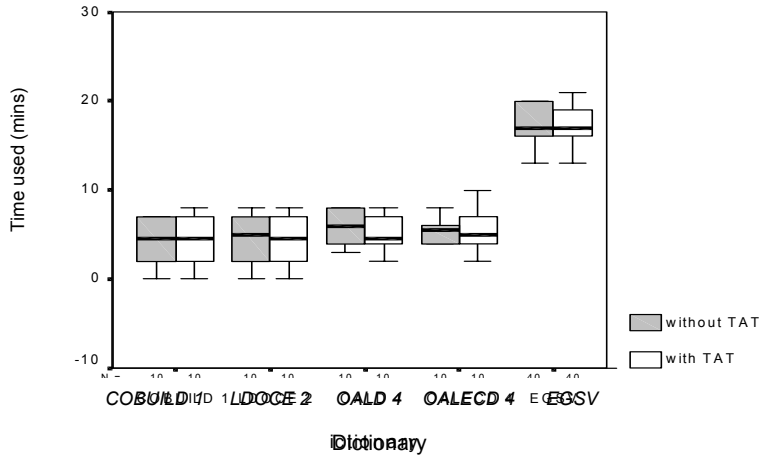

Figure 9: Comparison between the scores gained in the HOCT when the GLDs and the EGSV were used.

Results from the ANOVA in Figure 8 above show that there is a significant difference between the four means of the GLDs and the mean of the EGSV of correct scores subjects obtained. All subjects gained higher scores in the HOCTs when the EGSV was used than when the GLD was employed as a consulting tool. Individual means of the correct answers gained, when different dictionaries were used, are recorded in Table 9.

Table 9: Estimated marginal means of correct answers.

Estimated marginal means of correct answers gained		
consulting	**without TAT nor RI**	**with TAT and RI**
COBUILD 1	4	4
LDOCE 2	4	4.1
OALD 4	6	5.7
OALECD 4	5.2	5.8
EGSV	**17.5**	**17.5**

These findings are confirmed in Figure 9, where both the white and shaded boxes indicate that subjects gained more correct scores from the HOCTs when the EGSV was consulted than when the GLDs were used. The range of correct scores of the four GLDs and the EGSV, gained by the 80 subjects, is listed in Table 10.

Table 10: Correct answers.

Correct answers gained		
consulting	**without TAT or RI**	**with TAT and RI**
COBUILD 1	2–7	2–7
LDOCE 2	2–7	2–7
OALD 4	4–8	4–7
OALECD 4	4–6	4–7
EGSV	**18–20**	**18–19**

The findings consistently show that all subjects used less time, and obtained more correct scores, when they consulted the EGSV than when they consulted the GLDs. Similarly, data from the TAT and the RIs re-

vealed that subjects generally felt that it was much easier to locate the appropriate meanings of the vocabulary items under investigation in the EGSV than in the GLDs.

Summary

The ANOVA indicates that the effect of the use of dictionaries in the experiment is highly significant, implying that the use of a dictionary plays an important role in subjects' understanding of semi-technical vocabulary items in CS-related texts. The use of the thinking-aloud technique generally prolongs the duration of the experiment. Nevertheless, taking out the thinking-aloud variable, more time was still required when the GLDs were used as a consulting tool than otherwise.

With respect to the comparisons of the time used and the correct scores obtained, the results of correct scores obtained from each of the GLDs are very similar to each other. The performance of the subjects using the EGSV is significantly better (i.e. they obtained more correct scores) than when they consulted any of the GLDs.

The results also show that the subjects generally used less time to finish the HOCTs, but gained more correct scores, when the EGSV was consulted. When the GLDs were used, although the subjects took longer to sort out the HOCTs, they still failed to complete the tasks correctly. All the results collected in this study consistently confirm that a corpus-based subject-specific glossary of semi-technical vocabulary is a more efficient consulting tool for the first-year students at UST than a general learner's dictionary, in terms of ease of use and time required for consultation.

Conclusions

The semi-technical vocabulary items selected in this study mostly belong to the category of figurative usage. When words such as *run*, *open*, *insert*, *page*, *file*, *copy* and *call* appear in CS-related texts (e.g. word-processing program manuals), they take on extended meanings, i.e. become polysemous, in most cases through metaphorical adaptation. These words pose problems to ESP learners and are difficult to interpret in CS texts where they carry senses that readers may not know. Such words as *interrupt*, *group*, *view*, *label* and *file* may undergo linguistic variation in the form of grammatical conversion, a procedure which creates comprehension problems for students. In the CS context, the words under investigation

are semantically and stylistically different from their use in general texts without, however, being obviously technical.

The assumption that semi-technical vocabulary adversely affects students' understanding of CS-related texts, was established by the MCQS and the HOCTs, supplemented by the TAT and the RIs. The results from the MCQSs confirm this assumption. The 425 subjects were able to recognise and correctly explain the general meaning of the selected CS vocabulary items *run*, *open*, *insert*, *file*, *key*, *view*, *send*, *colour*, *function*, *index*, *command*, *sequence*, *cell*, *selection*, *format*, *list*, *frame*, *link*, *code*, *mode*, *field*, *copy*, *update* and *page*. However, when these words appeared in CS texts, not a single subject was able to interpret all the words correctly. The fact that fewer than 10% of the subjects were able to obtain 60% of the correct scores for the semi-technical vocabulary items used in the MCQS further suggests the adverse effect of this type of vocabulary on students' comprehension of CS texts.

This assumption is further validated by the results gathered from the HOCTs, in which subjects were asked to transfer their knowledge of the semi-technical vocabulary items from the cognitive level to practical tasks in a computer word-processing program. The results indicate that without knowing the figurative meaning (usually the result of metaphorical extension) of the words under investigation, the subjects were unable to complete a given task using *Microsoft Word 6.0*.

The assumption that a corpus-based subject-specific glossary of semi-technical vocabulary is a more efficient consulting tool for students than a GLD was established by comparing the use of four GLDs (*COBUILD 1*, *LDOCE 2*, *OALD 4* and *OALECD 4*), with a prototype corpus-based subject-specific electronic glossary of semi-technical vocabulary (ESGV). Results gathered from the 100 subjects, in both the pilot and main study (using two different approaches to comparing the two types of dictionary) indicate that a corpus-based subject-specific glossary of semi-technical vocabulary is a more efficient consulting tool for students than any of the GLDs, in terms of ease of use and time required for consultation. The ANOVA results indicate that the presence of a dictionary has a significant effect on whether the TAT has been employed or not. Subjects spent much less time to complete the HOCTs, and obtained significantly higher scores, when the ESGV was used.

Limitations

In all, 100 and 525 subjects participated in the pilot and main studies respectively. Although the scale of the research is sufficient to confirm the initial assumptions, and the subjects came from a selection of Departments which require students to read CS-related literature, the experiments did not cover students from other Departments such as Chemical Engineering, Civil Engineering, Marketing, and Finance, where computer skills are also required. Ideally, further studies should be extended to a wider range of students who need computer skills to fulfil their academic requirements.

The research techniques employed (DWLGE, MCQS, HOCTs, TAT and RI) are all shown to be effective in confirming the assumptions proposed in this study. However, in order to yield more informative data, each of the techniques, when used in conjunction with the others, could be improved by, for example, the use of tape-recordings (for the DWLGE); the use of the TAT and the RI during and after the MCQS; an increase in the number of vocabulary items, from a variety of CS-related sources, investigated; the use of focus groups for the RIs; the use of a different selection of dictionaries; the implementation of CD-ROM technology for the ESGV.

Recommendations for future research

The results of the experiments suggest that the semi-technical vocabulary items selected in this study not only have a negative effect on students' comprehension of CS textbooks but also directly affect their efficient use of new computer programs. The results indicate that at the sentence level polysemous general English words with extended meanings in CS, especially those used metaphorically, are the most problematic for learners. In most cases, even when longer texts were given, subjects were unable to guess the meaning of the words under investigation. Such an outcome suggests that teachers should develop an awareness of students' difficulties in comprehending the semi-technical vocabulary in CS texts. Subject teachers usually take time to explain strict CS terms to their students when these terms first arise, but seldom pay much attention to what we have identified here as semi-technical words.

The subjects' poor performance in the MCSQ suggests that many students at UST have not attained a sufficient threshold level of competence in English to enable them effectively to learn CS in English. Such findings

should alert subject teachers to the need to reassess the medium of instruction they use in teaching computer studies in tertiary education. Since the medium of instruction is a very controversial and complex issue in Hong Kong and its choice is determined more by social, economic and political factors than by the findings of educational research (Lam 1997), I will in this study indicate only two possible courses of action. Either students diagnosed as having low proficiency in English at their universities should be channeled to CS tutorial groups held in Cantonese, or steps should be taken to increase the amount of teaching of English at tertiary level in general. Any such development, however, would require effective language planning, systematic research, and a greater investment of resources than at present available. If the latter course of action were to be taken, the findings of the present research could be used to inform lecturers in CS of the nature of the difficulties students face in comprehending semi-technical vocabulary.

The subjects' poor performance in the HOCTs also indicates that semi-technical vocabulary not only affects their study of CS, but also that of all those students who need to use computer programs to assist their learning in their university studies as well as in their future careers. Problems with this type of vocabulary can prevent subjects from using computer programs effectively. The most direct solution would be to strengthen students' awareness of the nature and use of semi-technical vocabulary items in the first computer programs they meet. Subject teachers can either explain these items in their lectures, or provide the students with a glossary of semi-technical vocabulary to enable them to find the necessary word meanings.

The findings of this study strengthen the case for examining the semi-technical vocabulary used in a particular technical subject and a specific genre, for example in program manuals. Data from such investigations could shed light on the lexical features of the current texts in the subject, and therefore help in the compilation of useful instruments for its study, such as specialist glossaries. Some specific recommendations are:

1. Language practitioners, especially teachers, should be alerted, so as to help their students appreciate the nature and effect of semi-technical vocabulary items. They can test and ascertain their students' comprehension of these words and provide them with practice in their use. The present study provides information on a selection of problematic semi-technical words which should be useful for this purpose.

2. ESP teachers, subject teachers and others should familiarise their students with the semi-technical vocabulary items appearing in the CS-related texts that they will encounter later in their prescribed reading. This will not only help students to understand the use of the semi-technical vocabulary items in a particular text, but will also familiarise them with the language system that computer enthusiasts use to identify themselves as a distinct professional group. Feeling that they are becoming part of the 'club' will help students become more confident in handling CS-related texts and computer programs, which are necessary components of their academic study.

3. A glossary of semi-technical vocabulary should be added to individual CS textbooks, either as an appendix or a separate entity. Glossaries should be incorporated interactively as part of the on-line help manual for each computer program, like the prototype glossary used in this study. This glossary of semi-technical vocabulary stresses the importance of the clarity of word definitions provided, and is constructed so as to pinpoint the user's needs. In this study, the interactive on-line 'demo' feature appropriately supplements what has been left out of the definitions and therefore enhances users' understanding of the vocabulary items searched for. Other features, such as the first language of the users (in this study, Chinese), also prove to be useful in assisting users to achieve a more thorough understanding of the words searched for. Another feature worth including is the information about word frequency, which will not only help users to decide which words they want to learn first, but will also assist ESL practitioners and lexicographers to compile relevant wordlists for their purposes. One of the advantages of frequency information would be to improve the use and design of learners' dictionaries. Learners could also benefit from using concordancing techniques to search for current usages that appear in different types of texts by referring to examples given in such a bank of English materials.

4. The decision on the inclusion of lexical items in a specialised dictionary, as suggested by Tong (1993a), can be made systematically with the help of frequency lists generated from a subject-specific text collection, such as the James *cum al.*'s (1994) UST CS corpus. According to Tong, an entry in such a glossary should have the following characteristics:

    (a) the various definitions for different senses of the headwords should be sequenced according to their frequency of occurrence;

(b) the number of occurrences and the number of examples in which the occurrences appear should be given so that the reader will become aware of the commonness of the use and the width of representation of any entry;

(c) other than definitions, examples of the typical use of headwords should be provided from concordanced data. Common collocations, with frequency-of-occurrence figures, should be provided so that ESP learners can know how such vocabulary item can be used in context.

Producing practical ESP materials and useful tools to help learners acquire adequate English language skills to study necessary academic subjects is not a mission that single individuals can shoulder. It should be a well-planned, properly financed project that would attract a team of dedicated ESP practitioners, subject teachers, lexicographers, publishers, computer personnel and sponsors working together in interdisciplinary teams in order to develop a satisfactory curriculum and produce appropriate aids for learners in the field.