CHAPTER 5

FINDINGS

5.1 Introduction

This study focuses on five main research questions, all of which evaluate the CAT (computer-assisted tutorial) "Random Variables".

Formative evaluation is a cyclical and ongoing process (Beyer, 1995; van Niekerk, 1995). In this study, formative evaluation "zoomed in" to the instructional design model in four micro-stages:

- expert review
- prototype
- pilot test
- field test.

Table 5.1 shows which research questions were addressed during each of the micro-stages.

Question	Expert review	Prototype	Pilot test	Field test
1. Corrections and modifications?	✓	✓	✓	✓
2. Cultural and language implications?	✓			✓
3. Teaching approach?	✓		✓	✓
4. Use of function keys and icons?	✓	✓	✓	✓
5. Opinions, feelings and emotions?				✓

Table 5.1 Research questions and micro-stages

This chapter describes the findings that emerged and attempts to answer the five main research questions, which are discussed in turn in the sections that follow.

5.2 Biographical data

The following tables and figures reflect the biographical details of the respondents, in terms of gender, age, home language and computer usage. All figures are percentages, unless otherwise stated.

	English	Afrikaans	African	Other	**Total**
Male	12	36	24	4	**76**
Female	0	8	16	0	**24**
Total	**12**	**44**	**40**	**4**	**100**

Table 5.2 Gender and home language of the respondents

Table 5.2 shows that the students participating in the field test were largely male, with home languages fairly evenly split between Afrikaans and an African language. The computer-assisted tutorials are available in English only, so language is a concern. The use of language is discussed in section 5.4.

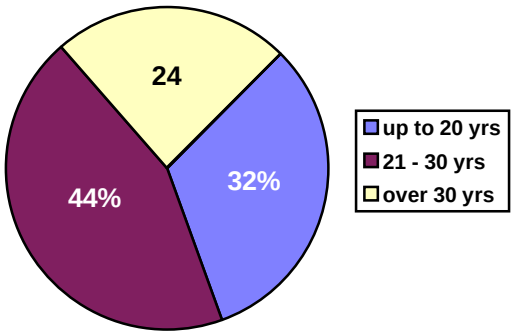


Figure 5.1 Age of the respondents

Figure 5.1 shows that the respondents are largely in their twenties. The average age is 25 years.

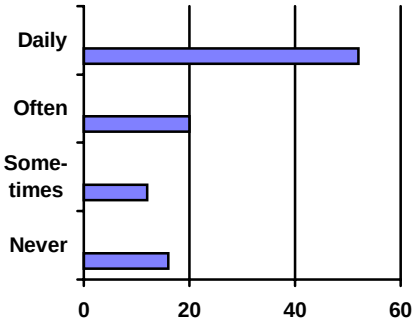


Figure 5.2 Computer usage of respondents (%)

As shown in Figure 5.2, the familiarity of the students with computers was surprisingly high, with only 16% reporting that they never use computers. Observation during the field test also showed that, given initial instructions as to how to run the tutorials, the students exhibited no problems with the use of the computer as a medium. This allays a concern that had existed prior to the field test, that computer illiteracy might have been a problem.

Computer Science and Information Systems is commonly studied concurrently with Statistics. Of the 25 students in the sample, 13 are, or have been, enrolled for modules in Computer Science and Information Systems. These students are well versed in the use of computers for various applications, as well as in programming and writing their own software systems. The telephone interviews, conducted with 12 of the students in the sample, revealed that 11 of them have computer hardware of a high standard at home and/or in their work places. The telephone interview scedule and its results are given in Appendix H.

It must be remembered, however, that there are students who do not have computing facilities of any sort at home or at work. These students rely on the computer facilities available at the Unisa micro-computer laboratories. Because of the small sample of students who participated in the field test, we cannot generalise about the extent of computer facilities and computer literacy. However, a survey carried out by Unisa in 1995 revealed that from a large sample of 50 000 respondents, 47% already own or have access to computers and many more intend to buy a computer in the near future (Schutte, 1996).

An indication of the time taken to complete the two tutorials was required for future reference, in order to give guidelines to students as to how long to expect to spend per tutorial. Sixty eight percent of the group spent between two and four hours per tutorial. Ninety six percent reported that the time available during the field test for the tutorial "Random Variables" was too short.

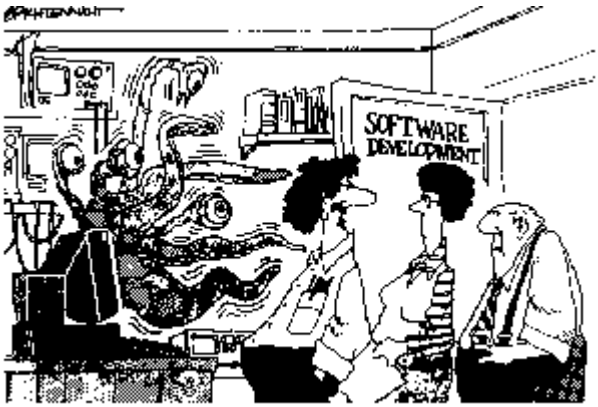
In practice, this should not present a problem, since it is not necessary to complete a tutorial in one sitting. All the tutorials record completion data, so that an individual student can continue later, without losing credit for sections completed. This assumes that the student is working on his or her own computer at home or at their place of work. If the students use the tutorials at the Unisa micro-computer laboratories, then the completion data on the network will be overwritten by the next student using a particular workstation.

5.3 Corrections and modifications to the program

The first main research question is:

"What corrections and modifications to the program are required?"

According to Beyer, *"formative evaluation is exactly what its name asserts. It is formative. Its results are intended to shape or* ***form*** *the content, structure, or other features of a product being developed"* (Beyer, 1995, p.8). This formative evaluation process is addressed by this research question and depicted in the cartoon overleaf.



Tennant (1996)

Expert Review (Design stage) and
Prototype (Development stage)

At each stage evaluation notes were made by the evaluators and the changes and edits were then implemented by the author. Since the group of evaluators included both subject matter experts and CAI experts, the content, didactic approach and instructional design features were routinely monitored.

The input from all these sources was valuable in highlighting ambiguities and inconsistencies, as well as in contributing added value to the tutorials. The final reports from peer reviewers are reproduced in Appendix I.

Pilot Test (Development stage) and
Field Test (Implementation stage)

Staff who participated in the Pilot test made valuable suggestions as to how the questionnaire could be improved. The most notable among these were instances when additional or different alternatives were desirable in responding to a particular question. For example, some questions offered the responses “Yes” or “No” and it was suggested that the option “Sometimes” be included, because a binary option was too strong. In some other cases when the options “Strongly Agree”, “Agree”, “Disagree” and “Strongly Disagree” were available, it was suggested that “Always”,

"Sometimes", "Never" would more accurately reflect the learner's response, since deciding between four degrees of comparison was not necessarily applicable.

The practical difficulties in creating a valid and reliable questionnaire were demonstrated in this project. Even after several revisions and input from experts, it is difficult to avoid ambiguities and misunderstandings. An example of this was the use of the word "academic". The author intended the use of the word in the sense of the language of the CATs perhaps being too academic, too formal, expecting a majority of "No" replies. However a majority of "Yes" responses was noted, indicating that most students, in agreeing that the language was "academic", appeared to attach a desirable connotation to the word, in the sense of "erudite" or "learned".

In addition to the questionnaire (Appendix F), participants in both the pilot test and the field test were provided with an error log (Appendix G). This offered them the opportunity to record exact details of any typographical errors, content errors and technical hitches, such as correct answers being rejected, incorrect answers being accepted, the program "hanging" etc.

Of the 25 students who completed the questionnaire, only six found it necessary to make some comments and suggestions on the error log with regard to "Random Variables".

Some of the comments were of a general nature, such as requiring a print facility for certain tables and the glossary. One student requested a printable score card.

Some valuable suggestions were made with regard to a particularly complex sequence of questions, which needs to have a print facility to record progressive answers, as well as additional "Back" options to review tables.

In general the comments on the error log were suggestive of enhancements and no actual errors or misrepresentation of content were identified. This indicates that the earlier micro-stages of formative evaluation were successful in eliminating content and typographical errors.

From observation during the field test, it was clear that most of the students were motivated by the CATs and enjoyed using them. It was clear from the telephone interviews that the students found the CATs a helpful supplement to their studies in Statistics and will return to them for revision purposes prior to the examination in October 1996.

The responses on the questionnaire pertaining to the first research question are discussed in the following paragraphs. In interpreting the percentages in the tables that follow, the reader should bear in mind that a frequency of 18 out of 25 students (72%) is considered to be statistically significant according to the binomial test (Hollander & Wolfe, 1973). The shaded areas in the tables indicate statistically significant figures.

Screen displays

	Always	Sometimes	Never
Uncluttered	70%	26%	4%
Neat	92%	8%	--
Too full	8%	56%	36%
Consistent	64%	32%	4%
Artistically appealing	75%	25%	--
Helpful in attracting and maintaining attention	80%	20%	--

Table 5.3 Description of the screen displays (n=25)

Table 5.3 shows that the majority of students found the **screen displays** to be uncluttered, neat, consistent, artistically appealing and helpful in attracting attention. Attention-gaining is an important initial event of instruction as defined by Gagné (1985).

Fifty six percent of students found that the screens were sometimes too full. This can be attributed to the nature of the subject matter, in that mathematical symbols, equations, diagrams, super- and subscripts are essential components and very often tend to fill the screen.

Text layout

	Yes	No
It is easy to read	88%	12%
There is too much text on one screen	12%	88%
It is attractive	100%	--
It is helpful in focusing attention	92%	8%
It is the same as reading text in a text book	16%	84%

Table 5.4 Description of text layout (n=25)

Table 5.4 shows that there was no problem with too much text on one screen and 84% of the students found that following the computer tutorial was not the same as reading text in a text book. This underlines the designer's attempt to optimise the attributes of the computer and to avoid producing an *"electronic page turner"* (Delpierre, 1991, p.63).

Use of colour

	Yes	No
It is consistent	96%	4%
Some colour combinations are difficult to distinguish	28%	72%
It is effective in focusing attention	92%	8%
Too many colours are used	8%	92%

Table 5.5 Description of the use of colour (n=25)

Table 5.5 shows a positive reaction to the use of colour in the tutorials. Four students remarked that they had difficulty distinguishing dark blue on a dark grey background (in the tutorial on Probability). This will be modified in version three.

5.4 Cultural and language implications

The second main research question is:

> "What are the cultural and language implications for the heterogeneous student population?"

Cultural issues

In catering for the multi-cultural target population, concerns had existed that ideas, symbols and/or situations used in the CATs might not be acceptable to all cultural groups. For example, certain colour conventions accepted in Western/European cultures, such as "green for go", "red for stop/danger" etc., may have different (perhaps adverse) connotations in different cultures.

Similarly, symbols such as an owl representing wisdom, may have adverse connotations for people of different cultures. Known difficulties were expressly avoided in the design of the CATs, and the field test showed that there are no unintentional occurrences of cultural embarrassment, as can be seen in Table 5.6.

Statement	Strongly agree	Agree	Disagree	Strongly disagree
12. The lessons assumed a different cultural background to mine.	--	4%	40%	56%
13. The lessons are acceptable to my cultural group.	46%	46%	4%	4%

Statement	Yes	No
19. Some colour conventions made me uncomfortable, e.g. red for incorrect answers.	8%	92%

Table 5.6 Cultural issues (n=25)

Statement 13 validates statement 12 in that 96% of respondents disagreed that a different cultural background was assumed, and 92% agreed that the cultural aspect of the lessons is acceptable to their cultural group. Statement 19 shows that there are few difficulties with the colour conventions used in the CATs. Two students marked this option, but only one reported what caused his discomfit - “red and blue for question marks”, which does not yield much information.

Language implications

The CATs are available in English only at this stage. The study guide, however, is available in either English or Afrikaans, and Afrikaans-speaking students, who are familiar with the technical terminology and definitions in the Afrikaans study guide, had difficulty in mentally translating these for use in the CATs.

Statement	Elementary	Intermediate	Advanced
32.I found the level of English usage in the computer lessons to be:	28%	64%	8%
33.I found the vocabulary used in the computer lessons to be:	13%	83%	4%

Table 5.7 Language issues (n=25)

Table 5.7 shows that even though only 12% of the participants are mother tongue speakers of English (section 5.2), there were few difficulties with the level of English usage and the level of vocabulary. Seventy two percent of the students found that the tutorial “Random Variables” is free from vague and ambiguous language.

The open statements and the error log gave the students the opportunity to express further opinions about the use of English. Seven of the 25 students (28%) reported difficulty with following the English terminology after having studied the Afrikaans study guide.

To the question “Is there any vague or ambiguous language, one student replied “At first - my background is Afrikaans, but during the lesson I got used to it.” Another student replied: “It was difficult for me to translate from Afrikaans to English (because I did not know the English terminology), so I couldn’t answer the question.”

Clearly there will be some language difficulties for all students whose mother tongue is not English. Until now, available resources have allowed the creation of the tutorials in one language only. Further research may support the need to translate them into other languages.

5.5 Teaching approach

The third main research question is:

> "Does the teaching approach embodied in the program contribute to perceived learning gains?"

As discussed in Chapter 2, a need exists for teaching and learning material in Statistics which encourages a deeper intuitive understanding of the basic concepts. In designing these CATs, a special effort was made to avoid the formal approach of written material such as study guides and text books, and to exploit the graphics and animation capabilities of the computer.

Two statements in particular, yielded encouraging results on this point, which are reflected in Table 5.8.

Statement	Strongly agree	Agree	Disagree	Strongly disagree
15. The way in which concepts were presented allowed me to develop a deeper understanding.	60%	40%	--	--
16. The way in which the learning material was presented required me to memorise meaningless definitions and theorems.	4%	20%	48%	28%

Table 5.8 Teaching approach (n=25)

Statement 15 expected a positive response, and as a validation, statement 16 expected a negative response, which is exactly what happened.

Another statement which anticipated disagreement was about the level of prior knowledge assumed. The findings are shown in Table 5.9.

Statement	Strongly agree	Agree	Disagree	Strongly disagree
11. The lessons assumed more mathematical background knowledge than I have.	4%	16%	28%	52%

Table 5.9 Assumed prior knowledge (n=25)

This result clearly shows that the level of assumed prior knowledge is acceptable. Cognitive scaffolds which support the student who may have gaps in his or her prior knowledge, are the **glossary of statistical terms** and the **pop-up help windows** which are available when certain terms, concepts and notation are used for the first time (see examples in Chapter 3).

It was clear that the students had a positive impression of their perceived learning gains. Eighty eight percent of respondents reported that they had learnt some statistical concepts that they didn't know before.

Statement 42	Yes	No
These computer lessons help to make Statistics more interesting.	96%	4%
These computer lessons help to make Statistics more understandable.	100%	--

Table 5.10 Perceived learning gains (n=25)

Table 5.10 reflects the strong perception that the CATs help to make the subject of Statistics more interesting and more understandable. These factors contribute to building learner satisfaction and confidence, which are important motivational principles (Keller & Burkman, 1993).

With regard to the question-answer-feedback episodes, three areas needing attention emerged:

- instructions on how to answer questions;
- the number of questions provided and their difficulty level;
- feedback after wrong answers.

These issues are discussed in turn below.

Instructions on how to answer questions

Only 56% of students felt that instructions on how to answer each question are always clear. The remaining 44% of students felt that the instructions were sometimes clear. Two students requested that there should be a flashing cursor when an answer is required (although there is an arrow which indicates that input from the student is awaited). Clearly there was still some confusion as to when the student was required to type in an answer.

The number of questions provided and their difficulty level

There was a feeling that more questions of varying difficulty levels would be helpful, as shown in Table 5.11.

	Specific item	Open statements
Number of questions	56%: not enough	48%: not enough
Difficulty level of questions	84%: average difficulty	16%: would like a greater variety, of various difficulty levels.

Table 5.11 Number of questions and their difficulty level (n=25)

Table 5.11 shows that there was some feeling that there are not enough questions and exercises. In the open statement, 16% of students remarked that they would like

a greater variety of questions, of various difficulty levels, and more advanced questions, as appear in assignments and can be expected in the examination.

It should be borne in mind that the intention of a computer-assisted tutorial is primarily to teach and not to test (Alessi & Trollip, 1991). The questions that are interspersed in the presentation of learning material are intended to be quick self-assessment checks for the student to make sure that he or she is following the line of thought and is able to apply the concepts presented. A topic for further research may be to investigate the design and development of computer-based tests that will meet the need of the students described above.

Feedback after wrong answers

In Statement 40 on the questionnaire, 56% of the respondents felt that they had always learnt from the feedback after a wrong answer, with 40% responding that this had sometimes been the case. One of the peer reviewers commented that the feedback, although adequate, is not very ambitious (Appendix I).

The developer is aware of the power of feedback as an instructional tool (Gery, 1988) and an effort was made to anticipate possible incorrect responses and to provide specific feedback. In the case of statistical questions, many of which require numerical input, it is not always easy to anticipate mistakes that the student may make during the course of their calculations. A technique that was used to support the student through the calculation process, was to guide the student to enter progressive results, for which it was easier to provide specific feedback. This is another point that deserves further consideration and investigation.

5.6 Use of the function keys and icons

The fourth main research question is:

> "Is it clear how to use the function keys and icons to navigate through the program?"

Statements 23 to 27 on the questionnaire referred to the movement within the lessons. The findings are given in Table 5.12.

Statement	Always	Sometimes	Never
23. The directions for lesson control are clearly stated.	76%	20%	4%
24. The icons are easy to use.	80%	16%	4%
25. I experienced problems in selecting a topic from the menus.	--	8%	92%
26. It is easy to see which menu levels have been completed.	96%	--	4%
27. The main menus and sub-menus disoriented me.	--	12%	88%

Table 5.12 Navigation (n=25)

Some statements (e.g. statements 25 and 27) were phrased in such a way that a negative response was desirable, and these yielded the expected outcomes. Table 5.12 shows that little difficulty was experienced with movement within the lessons and the use of menus.

Regarding the use of the function keys for specialised actions, the majority of students found the "Back", "Replay", "Glossary", "Repeat questions", and pop-up

windows useful. Surprisingly, only 60% of the students found the "Where am I?" feature (see example in Chapter 3) useful and 32% found it unnecessary.

5.7 Opinions, feelings and emotions of the learners

Traditionally, instructional outcomes have been divided into three domains, the cognitive, the affective and the psycho-motor domains (Bednar & Levie, 1993). The concepts of learner attitudes, feelings, motivation, beliefs and opinions are associated with the affective domain, a vital area so often neglected:

> *"What has received relatively little attention by instructional technologists and designers is the development of instruction that incorporates affective goals, objectives and strategies into educational programs and practices"* (Martin & Briggs, 1986, p.*xi*).

The fifth main research question concerned the affective domain:

"What are the opinions, feelings and emotions of the learners on completion of the program?"

Gloria Gery phrases the importance of investigating the affective domain as follows:

> *"**But Do They Like It ?** We all want learners to feel good about the instructional delivery. So when you evaluate CBT, you should ask questions about how they 'liked' the courseware. It is equally important to find out what they liked or disliked and why"*
> (Gery, 1988, p.197).

Opinions about the graphics

The opinion of the students was sought with regard to the graphics used in the CATs (pictures, diagrams, illustrations, arrows, boxes etc.). Ninety two percent of the respondents agreed that these helped them to understand the content.

In “Random Variables”, the theme character that leads the interaction with the student is a white rabbit, and opinion was sought as to its usefulness. The findings are given in Table 5.13.

The white rabbit character is:	Yes	No
Amusing	67%	33%
Childish	8%	92%
Offensive to my culture	--	100%
Useful in breaking up the text	96%	4%
Useful in providing light relief	96%	4%

Table 5.13 The opinion of the white rabbit theme character (n=25)

With reference to Table 5.13, 67% of the respondents felt that the character is amusing. The moderate use of humour can serve to motivate the student (Alessi & Trollip, 1991; Malamed, 1991) and cause the learning experience to be memorable.

Two concerns about the white rabbit character had been that it might be offensive to different cultures and that for adult learners, it might be regarded as rather childish. Table 5.13 shows that these concerns were groundless.

Table 5.13 also shows that the majority of the students felt that the white rabbit character is useful in breaking up the text and in providing light relief. Interludes of light relief can help to reduce cognitive fatigue, which could otherwise result from insufficient variety in the task at hand, as shown by research on human-computer interface (Jih & Reeves, 1992; Marchionini, 1992).

Other opinions, feelings and emotions of the learners

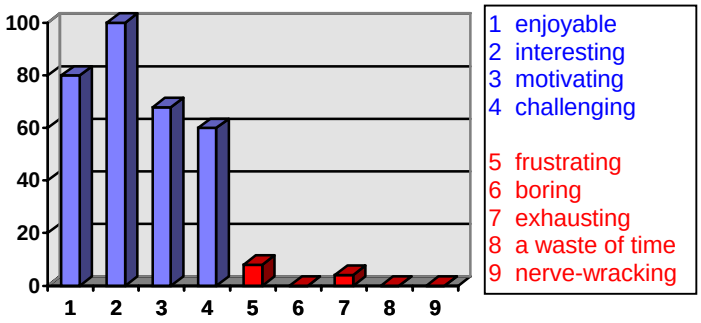


Figure 5.3 Learners' opinions about the tutorials (%)

Figure 5.3 shows that the students clearly enjoyed working through the tutorials. Only two students reported that they found them frustrating, and one student found the tutorials exhausting. No students found them to be boring, a waste of time or nerve-wracking. In this item and the next, students were able to mark more than one option, so the resultant percentages are not expected to total 100%.

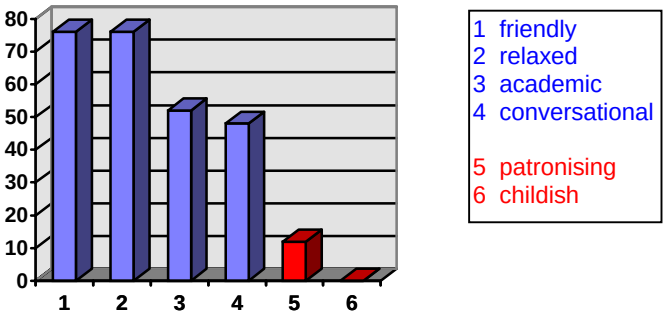


Figure 5.4 Learners' opinion about the tone of the tutorials (%)

Figure 5.4 shows that the students found the tone of the tutorials to be positive and acceptable. Fifty two percent of them marked the tone as being 'academic', but there may have been a different connotation attached to the word "academic", as discussed in section 5.3.

The questionnaire asked for feedback as to how students rate the tutorials. All the respondents would recommend the tutorials to other students.

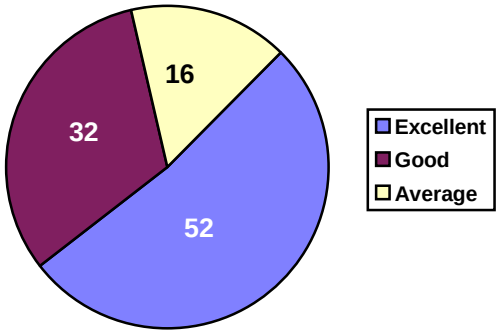


Figure 5.5 Student rating of the tutorials (n=25)

Figure 5.5 shows that the majority of the students rated the tutorials as “Excellent” or “Good”.

5.8 Qualitative feedback

The open statements on the questionnaire and the error log yielded encouraging comments. Some of these are listed below:

- “Animation is great!”
- “A fresh approach - I enjoyed it very much.”
- “Fun with Stats!”
- “I understand how to answer questions in Statistics.”
- “The definitions and concepts were fixed in my mind.”
- “The lessons helped me to understand and boosted my memory.”
- “These lessons motivated me and gave me courage for my studies.”
- “I learn faster and I can sit and study in front of a computer much longer than in front of a book.”
- “I know distribution functions.”

The telephone interviews afforded the students the opportunity to express their opinions to a greater extent than was possible with the questionnaire. To the question “Do you think the computer lessons will help with your revision before the exam?”, some of the responses were:

- “Yes, of course.”
- “Yes, most definitely.”
- “For sure - excellent.”

5.9 Summary

The Expert Review and Prototype micro-stages were effective in eliminating typographical, content and technical errors. The Pilot Test also contributed to this formative evaluation process, as well as shaping the design of the questionnaire.

The Field Test with students yielded constructive comments and suggestions.

The two main areas which caused problems for the students were:

- the use of English for the students who had studied the terminology in the Afrikaans study guide;
- the need for a greater number of questions, of varying difficulty levels, to match those in the assignments and examination.

Three valuable suggestions were made by the students:

- allow more “Back” navigation, especially within sequences of progressive questions which build on each other;
- be sure to have your study guide with you for reference purposes, when working through the tutorials;

- Unisa should consider increasing the course registration fee slightly and including the CATs as a package as part of the prescribed material, rather than requiring the students to purchase them separately.

Suggestions for further research are discussed in Chapter 6.