University of Pretoria

# Random Variables: A CAI tutorial in Statistics for distance education

A mini-dissertation

by

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submitted in partial fulfilment of the requirements for the degree

**Magister Educationis**

**in**

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# SAMEVATTING

## “Random Variables”: 'n RGO tutoriaal in Statistiek vir afstandonderrig

'n Skripsie

deur

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Graad : MEd (RGO)

Die navorsingsverslag dokumenteer die instruksionele ontwerpproses van 'n rekenaar gesteunde tutoriaal (RGT), "Random Variables", een van 'n reeks van nege soortgelyke tutoriale wat as aanvulling tot die geskrewe studiegids vir 'n eerstejaar kursus in Statistiek by die Universiteit van Suid-Afrika (Unisa) gebruik word.

Die instruksionele benadering wat in die RGT gebruik is, probeer om kognitiewe ondersteuning te verskaf en om 'n intuitiewe begrip van abstrakte konsepte aan te moedig. Die doel is om die geisoleerdheid waarin afstandsonderrig studente verkeer, te verlig en om groter interaktiwiteit met die studiemateriaal tot stand te bring.

Formatiewe evaluering het 'n sentrale plek in die instruksionele ontwerpmodel, wat analise, ontwerp, onwikkeling en implementering insluit, ingeneem. Die formatiewe evaluering is in vier mikro-stadia, naamlik vakkundige resensie, prototipe, loodstoetsing en veldtoetsing gedoen.

Die navorsingsresultate het daartoe gelei dat die tutoriale as sulks verbeter is. Dit kan ook verdere navorsing op die gebied van summatiewe evaluering rig en lei.

Die navorsingsverslag moet saamgelees word met die loop van die program “Random Variables”, wat op disket beskikbaar is.

# ACKNOWLEDGMENTS

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And, of course, I would like to express my gratitude to my own family, John, Daniel and Anna, for supporting and encouraging me throughout this study and for the additional burdens that they had to shoulder when I was engrossed in producing this research report.


> "Some fear that technology will dehumanize formal education. But anyone who has seen kids working together around a computer, the way my friends and I first did in 1968, or watched exchanges between students in classrooms separated by oceans, knows that technology can humanize the educational environment. The same technological forces that will make learning so necessary will also make it practical and enjoyable" (Bill Gates, 1995).

Here's to "The Road Ahead" (Gates, 1995) and the joy of watching our children learning with computers.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| **Unisa** | University of South Africa |
| **STA101-H** | Statistics 101 Course at Unisa |
| **CENSE** | Centre for Software Engineering |
| **S.A.** | South Africa |
| **CTI** | Computers in Teaching Initiative |
| **CAI** | Computer-Assisted Instruction |
| **CBL** | Computer-Based Learning |
| **CBT** | Computer-Based Training |
| **CATs** | Computer-Assisted Tutorials |
| **CBTs** | Computer-Based Tutorials |
| **SME** | Subject Matter Expert |
| **CAIE** | Computer-Assisted Instruction Expert |
| **L** | Learner |
| **R** | Researcher |
| **NAVO** | Database of S.A. theses and dissertations |
| **p.d.f.** | probability density function |
| **c.d.f.** | cumulative distribution function |

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# CHAPTER 1

# *BACKGROUND*

## 1.1 Introduction

This project started in May 1994, when work began on designing and developing a set of nine Computer-Assisted Instruction (CAI) tutorials which will ultimately supplement all the topics in the study guide for a first year Statistics module (STA101-H) at the University of South Africa (Unisa), Pretoria, South Africa.

The tutorials were designed, developed and programmed in the TenCore authoring language by the author of this research report. Although there are nine tutorials in the series, this study concentrates on the ongoing formative evaluation of one in particular, namely "Random Variables", which is the sixth in the series.

The tutorial "Random Variables" is provided on diskette together with this research report. Installation instructions are provided in Appendix B.

All the tutorials have undergone review by subject matter experts, as well as an expert review by CAI specialists in the department of Computer Science and Information Systems at Unisa. The tutorial “Random Variables”, in particular, has been pilot-tested with staff members and field-tested on a sample group from the target population. The findings and recommendations of this study will be transferred to the other tutorials in the series and will guide further development.

## 1.2 Research problem

### 1.2.1 Purpose of the research

This is largely an exploratory study, which evaluates the product, with a view to enhancing and improving the tutorials. It does not attempt to compare the effectiveness of the electronic versus the written medium, and therefore makes no use of control and experimental groups. It does not attempt to measure the amount of learning which takes place, and therefore makes no use of pre-tests and post-tests. These issues will provide the opportunity for further research (see Chapter 6).

### 1.2.2 Aim of the research

The aim of this research is to design and develop a computer-assisted tutorial "Random Variables" and then to investigate and evaluate the impact of this program on a sample of students from the target population.

### 1.2.3 Objectives of the research

In order to achieve the above aim, the researcher's objectives were to:

- analyse the target population, the subject matter and appropriate hardware and software;
- design the tutorial "Random Variables" according to an instructional strategy incorporating cognitive learning theories;
- develop and test the tutorial "Random Variables" using the TenCore authoring package;

- modify the prototype after peer review by subject matter and computer-assisted instruction experts;

- implement the six tutorials, which have been developed to date, for students to work through on their own computers or in the Unisa regional microcomputer laboratories;

- evaluate the tutorial "Random Variables" by obtaining peer reviews and student feedback about various aspects of the program;

- assess what changes and modifications are required to improve the tutorial "Random Variables".

### 1.2.4 Scope of the project

The project followed an instructional design model, which is described in detail in Chapter 3. The process consisted of various stages and micro-stages. Figure 1.1 gives an indication of the percentage of time spent on the major stages.

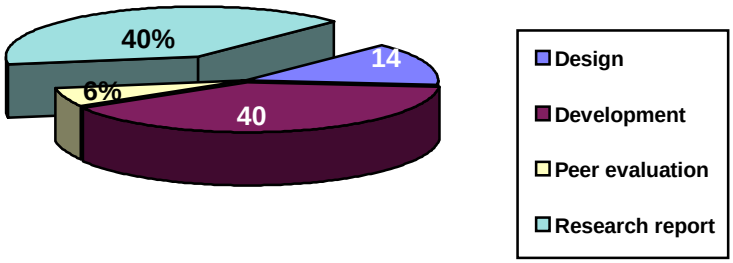


**Figure 1.1 Scope of major stages in the instructional design**

It can be seen from Figure 1.1 that the compilation of this research report took the same amount of time as did the development of the computer-assisted tutorial.

## 1.3 Research questions

### 1.3.1 Research questions

The following main research questions arise:

1. What corrections and modifications to the program are required?

2. What are the cultural and language implications for the heterogeneous student population?

3. Does the teaching approach embodied in the program contribute to perceived learning gains?

4. Is it clear how to use the function keys and icons to navigate through the program?

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

### 1.3.2 Previous related research in South Africa

The Human Sciences Research Council maintains a database (NAVO), which documents details of all Masters and Doctoral theses produced in South Africa. According to a search of this NAVO database conducted in August 1996, eight related studies were identified. These are detailed in Table 1.2.

| Author | Title | Year | Degree |
|---|---|---|---|
| Burger, J.A. | The use of the computer in distance education and learning in the studying of Biblical Archaeology (in Afrikaans). | 1995 | M.Ed. |
| Paynter, J.R. | A strategy for the integration of computers into the curricula of courses within the Accounting departments of South African universities. | 1988 | M.Com. |
| Soskolne, C.L. | A computerised statistical census relating to university education - a group of science and engineering students, University of the Witwatersrand. | 1974 | Non-degree |
| Theron, H.J. | Use of computers in the teaching of Auditing with special reference to distance education. | 1993 | M.Com. |
| Tromp, P.J. | A computerised information system for Economic Statistics (in Afrikaans). | 1982 | MBA |
| Young, D.A. | Computer-aided evaluation of television instruction in a tertiary-level introductory Statistics course. | 1980 | M.Ed. |
| Van Zyl, J. | Criteria for the evaluation of micro-computer software for the teaching of Mathematics at technical colleges (in Afrikaans). | 1983 | M.Ed. |
| Van Zyl, P.H.R. | A didactic model for the use of computer technology in distance education (in Afrikaans). | 1992 | D.Ed. |

**Table 1.1 Summary of related theses in S.A. (NAVO database)**

As can be seen from Table 1.2, the only two studies which use the computer in the field of Statistics, are those of Tromp and Young. However they do not use the computer in a tutorial or instructional mode, but respectively as a tool to create a database of information or to evaluate television teaching in a Statistics course.

The studies of Burger, Theron and van Zyl, P.H.R. consider the use of computer technology in distance education. Burger and Theron concentrate on the subject areas of Biblical Archaeology and Auditing respectively. Van Zyl presents a didactic model for employing computer technology in distance education so as to move away from a Victorian teaching model and to encourage independent thought and problem solving among students.

The M.Com. theses of Paynter and Theron consider the use of the computer as a tool in the fields of Auditing and Accounting. Soskolne also uses the computer as a computational and record-keeping tool. The study of van Zyl, J. presents criteria for the evaluation of software in the field of Mathematics Teaching.

The present study is thus the only one in South Africa to investigate the design and development of customised computer-assisted tutorials in Statistics, in a Distance Education institution.

## 1.4 Research methodology

### 1.4.1 Type of research

This research has elements of both an exploratory and a descriptive study. Mouton and Marais (1993) indicate that an exploratory study is usually a preliminary investigation to gain insight into a particular phenomenon. According to these authors, the spectrum of descriptive studies includes a large variety of types of research. In this particular case, the narrative nature of the research, together with its contextual interest, characterise it as a descriptive study.

### 1.4.2 Subjects

The subjects who participated in the field test were Unisa students registered for the first year Statistics module, STA101-H in 1996. Due to the difficulties of recruiting a sample of students at a distance education institution, a convenience sample (Cohen & Manion, 1994) was used. There were 339 students registered for the course in 1996, so a figure of 34 would have been a 10% sample (a guideline suggested by Lee & Mamone, 1995). Thirty five students replied to the invitation to participate in the study, with 25 finally taking part.

### 1.4.3 Research timetable

| ACTIVITIES | DATE |
|---|---|
| 1. Design and development of CAI tutorial (270 hours) | Aug-Oct 1994 |
| 2. Literature review | Jul-Nov 1995 |
| 3. Final proposal | Oct 1995 |
| 4. Pilot test | Jan 1996 |
| 5. Field test | Mar 1996 |
| 6. Data analysis | May 1996 |
| 7. Writing research report | June-Oct 1996 |
| 8. Final research report | Oct 1996 |

**Table 1.2 Research timetable**

### 1.4.4 Data collection methods

In order to increase the reliability of the study, a number of data collection methods were used to triangulate the findings (Mouton & Marais, 1993). These methods are summarised in Table 1.4, with reference to the research questions.

| Method / Question | Peer review Focus groups | Survey | Observation | Telephone Interviews |
|---|---|---|---|---|
| Corrections/ modifications? | SME, CAIE, R | L SME | R | |
| Cultural / language implications? | SME, CAIE, R | L | | |
| Teaching approach? | SME, CAIE, R | L SME | | L |
| Clear navigation? | SME, CAIE, R | L SME | R | |
| Opinions, feelings and emotions? | | L SME | R | L |
| **Data analysis method** | edits to storyboards and prototype | descriptive statistics; binomial test | narrative | discussion |

L = Learners
R = Researcher
SME = Subject Matter Experts
CAIE = Computer-Assisted Instruction Experts

**Table 1.3 Data collection matrix**

## 1.5 Overview of this research report

This research report is organised as follows:

- Chapter 2 presents a review of the literature in the fields of Statistics Education, Distance Education and CAI and places this particular study in the intersection of these three fields.
- Chapter 3 describes the analysis, design, development, implementation and formative evaluation of the tutorial “Random Variables”, with respect to an accepted instructional design model.
- Chapter 4 presents the research methodology used in this study, in particular the methods and instruments of measurement used.
- Chapter 5 describes the findings of the study.
- Chapter 6 draws conclusions and makes recommendations for further research.

A graphic overview of the flow of the discussion is given in Figure 1.5 overleaf.

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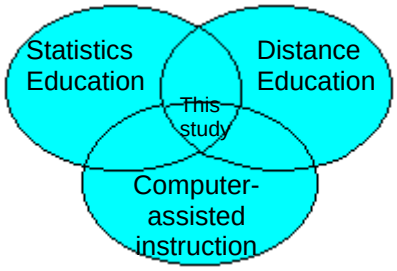
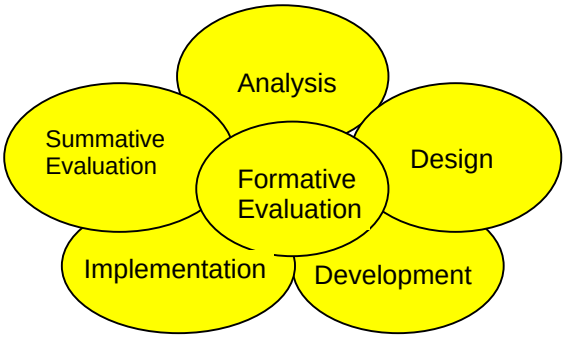
Chapter 2




Chapter 3

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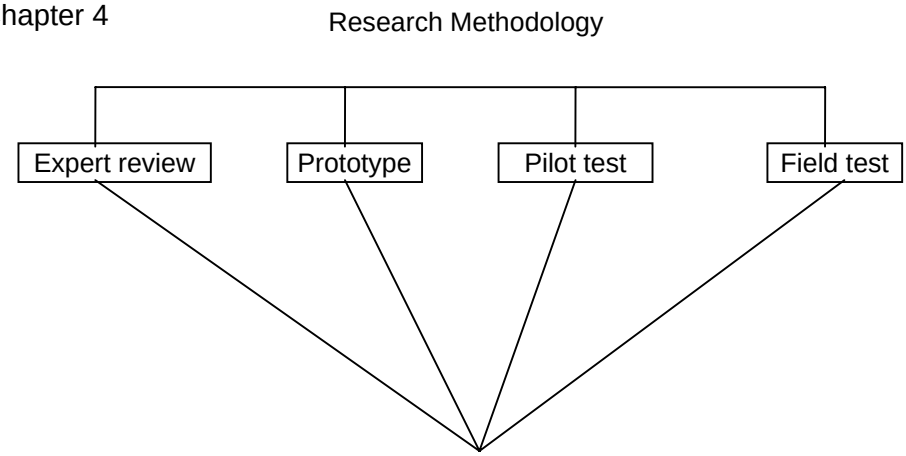


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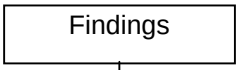



Chapter 6

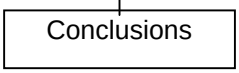



**Figure 1.2 Overview of the research report**

# CHAPTER 2

# *LITERATURE REVIEW*

## 2.1 Introduction

This study originated in considering how to enhance the teaching of Statistics at a distance education institution, the University of South Africa (Unisa), which is situated in Pretoria, South Africa. The figure below shows the overlap between these two fields of education.

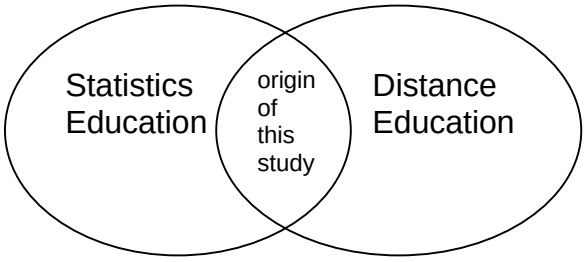



**Figure 2.1 The origin of this study**

The traditional medium of instruction used in distance education is the printed word. In considering additional methods and media, various issues such as the "method versus media" debate, materials production for distance education and constraints applicable to distance education arose. These issues informed and shaped this study as shown in Figure 2.2.

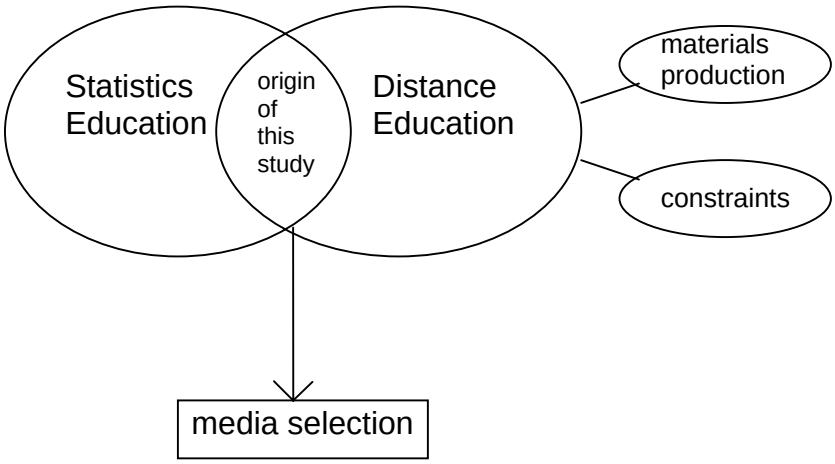



**Figure 2.2 Issues which shaped this study**

The side issues of **materials production** (design and development) and **constraints** in distance education are discussed in Chapter 3, so as not to detract from the linear flow of the concepts reviewed in this chapter.

The linear flow of this review continues then, from the teaching of Statistics in a distance education scenario, to the choice of supplementary media and methods. The medium of Computer-Assisted Instruction (CAI) is explored, with particular emphasis on the use of Computer-Assisted Tutorials (CATs), a subset of CAI, as shown in the final diagrammatic representation overleaf.

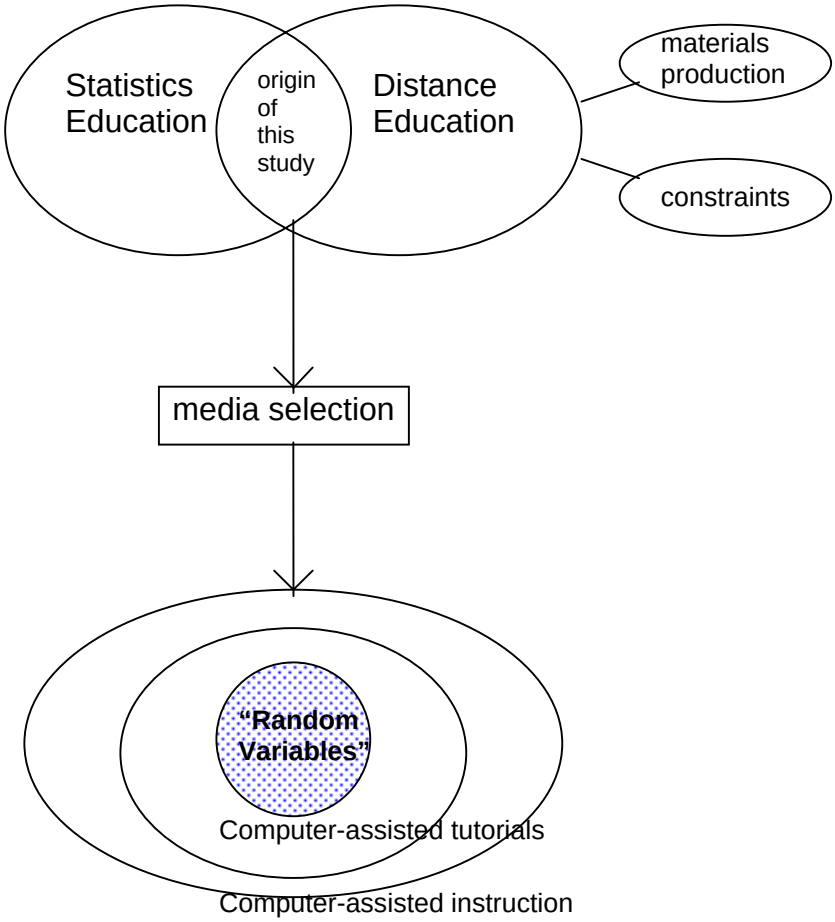



**Figure 2.3 The placement of this study in the field**

## 2.2 Statistics Education

### 2.2.1 The research process

Statistics today is a science that is used and applied by researchers in many different fields. The empirical investigation process is based on the collection, analysis and interpretation of relevant information. The aim of the scientist, in whatever branch of science, is to determine whether observed facts, data or behaviours support or contradict theories, and very often, statistical methods are employed as research tools.

The role of statistics in the research process is reflected in the following five-stage diagram:

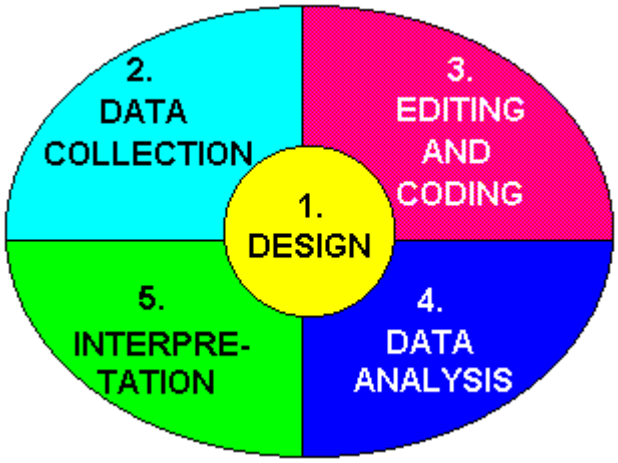



**Figure 2.4 The role of statistics in the research process**

From the above diagram, it can be seen that the design, or planning of the research project is central to the success of the project. Jeffers (1995) makes the important point that if due emphasis is placed on the experimental design, which includes careful consideration of the objectives of the investigation and identification of the most suitable method of analysis, then valid interpretation of the data is more likely. He goes on to say:

> *"No amount of clever analysis will make up for inappropriate design"* (Jeffers, 1995, p.231).

This philosophy finds a parallel in the philosophy of instructional design, where no amount of clever CBT (Computer-Based Training) will make up for inappropriate or inadequate needs analysis.

The use of statistical methods and experimental design as research tools in various fields is increasing. Therefore increased efforts are required to enhance the training of statisticians with a view to applying the theory in real life research situations.

### 2.2.2 The teaching of Statistics

In considering the teaching of Statistics, to both future statisticians and to non-statisticians, one must be aware of the distinction between **statistical packages** which are designed to perform complex statistical calculations, and **Computer-Assisted Instruction (CAI) tutorials**, which are designed to **teach**, i.e. to present information and to offer the opportunity for guided practice with immediate feedback.

Almost all data analysis will be carried out in future by non-statisticians with the aid of commercially available computer packages (Jeffers, 1995). Due to the availability of more and more increasingly powerful such packages, and the scarcity of other resources, these non-statisticians will be forced into greater self-sufficiency, but may not always recognise when their own understanding of statistical principles is inadequate to guide the choice of a particular method within the package, and the interpretation of the results.

The teaching of Statistics is becoming an increasingly debated issue. Both the theory and practice of the discipline are important, but is the theory perhaps being emphasised to the detriment of the practical application of statistical methods to sets of real data? Are tertiary institutions producing qualified statisticians who are able to fulfil the role of consultants and advisers to the many non-statisticians in science, industry and commerce, who rely increasingly on statistical methods to analyse and interpret their data?

Jeffers (1995) makes the following statement in underlining this dilemma:

> *As statisticians, we cannot be content to be marooned in an academic backwater, happily developing new and more refined mathematical*

> *techniques, while the rest of our professional colleagues remain largely unaware of the underlying philosophy of our methods, and the importance of gaining an understanding of the real world through valid samples obtained through experiments or surveys"* (Jeffers, 1995, p.233).

This is particularly important today, with the emphasis on valid and reliable research (Mouton & Marais, 1993), which needs to be interpreted and communicated in accurate and helpful ways. Finney (1995) states that

> *"Every scientist whose research is supported by public funds has a duty to make known his or her findings in a manner that may serve the public good and contribute to the store of human knowledge"* (Finney, 1995, p.293).

With the availability to non-statisticians of powerful computer packages for statistical analysis, it has become clear that there is a need for greater concentration on instruction, with a view to training users of statistical methods on the basic assumptions and constraints inherent in computer packages. According to Jeffers (1995),

> *"... the ability to perform a wide variety of statistical analyses with the aid of these program packages is not matched by adequate explanation for the non-statistician of the assumptions being made by those analyses, or of the constraints that are imposed by the underlying theory of the analyses. As a result, it is not uncommon for data to be analysed by the wrong methods, and, consequently, seriously misinterpreted. The ability to carry out the computations has now greatly outstripped the basic knowledge required to choose which computations should be carried out"* (Jeffers, 1995, p.229).

Besides being an academic discipline in its own right, Statistics is often offered as a service course necessary for other disciplines such as the human sciences, the natural sciences and the business sciences. And yet, scientific journals and research reports abound with examples of the misapplication of statistical methods and the

misinterpretation of results. Finney (1995) provides several examples of what he calls “anarchies and horrors” (p.295). Becker, Viljoen, Wolmarans and IJsselmuiden (1995) assessed the statistical procedures used in papers published in the South African Medical Journal during 1992 and found that 15 percent of them used inappropriate methods of data analysis:

> *“The ‘user-friendly’ nature of current statistical software has brought statistical data analysis within easy reach of the biomedical researcher, resulting in the frequent use and, knowingly or unknowingly, abuse of biostatistics”* (Becker et al., p.881).

Readers of journal articles in the experimental or observational sciences, and more importantly, users of the research results, such as government and business advisers, cannot be expected to identify and compensate for misrepresentations resulting from the misuse of statistical packages. It is the training and scholarly integrity of the researcher which must ensure solid experimental design and valid conclusions.

> *“There is an apparent need for an understanding of the basic principles of statistical inference and the use of analytical techniques”* (Jeffers, 1995, p.231),
>
> and again
>
> *“the cardinal understanding of the underlying logic of statistical methods seems to have remained hidden within a morass of mathematical complexity that makes that understanding illusive*” (Jeffers, 1995, p. 232).

The points mentioned above indicate that there is a need for innovative teaching materials, in the subject of Statistics, which encourage a deeper intuitive understanding of underlying principles and concepts. Researchers will then be able

to apply statistical methods wisely in practice, thus reaching valid conclusions that will contribute to human efforts in understanding the world around us.

This study evaluates customised computer-assisted tutorials that were designed and developed for first-year Statistics students, with special emphasis on portraying and demonstrating the underlying concepts in a meaningful and memorable way.

## 2.3 Distance Education

### 2.3.1 Context

The Open University in the United Kingdom and Unisa in South Africa are two world renowned institutions which offer distance education to thousands of students world-wide. Distance education offers an alternative route to accreditation and certification for students who, for a variety of reasons, may be unable to attend conventional universities.

Traditionally, distance education has been synonymous with studying by correspondence, in that the student population is generally widely dispersed, and the usual means of communication is by the printed word. Students receive the course material in the form of study guides, which are sometimes supplemented by prescribed text books. Students study the material on their own, in their own time. They generally have limited telephonic and written contact with their “lecturers” (course leaders who are not present in person during the learning process and do not, in fact, deliver lectures).

Naturally the element of **distance** brings with it the difficulty of the isolation of the student, which seriously impacts on the level of interaction that is possible. Johnson and Johnson (1991) highlight three types of interactions that are desirable in the traditional classroom situation and necessary in the collaborative classroom. These are summarised diagrammatically Figure 2.5.

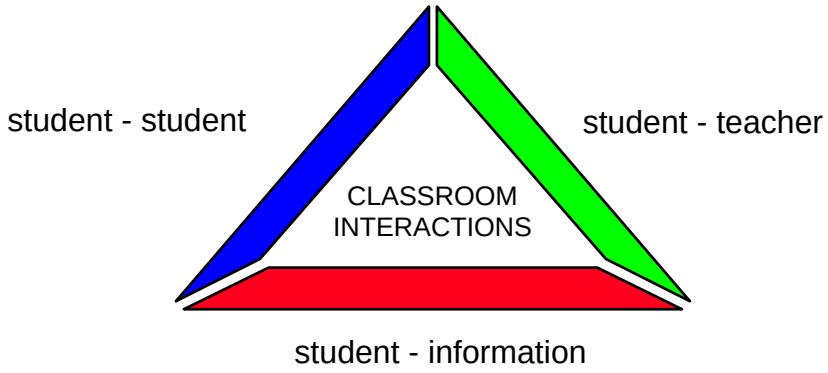



**Figure 2.5 Classroom interactions**

The above diagram shows the ideal of face-to-face human interactions in a classroom situation. Students at a distance university have to cope with feelings of isolation due to the lack of interaction with lecturers and fellow students (du Plooy & de Villiers, 1992). We need to try and emulate the ideal of the above triangle, by offering additional learning resources, methods and media.

In trying to counteract their isolation, students often form self-help groups or study groups for mutual support and interaction. In the case of Unisa, the regional centres organise discussion groups. The course organiser (lecturer) travels from Pretoria to the regional centres (currently at Cape Town and Durban) and conducts discussion sessions with small groups of students.

Besides this limited contact with subject matter experts and peers, the correspondence student generally has only the interaction with the study material that is provided. Today, several attempts are being made to overcome the resultant isolation, usually by introducing supporting study material making use of different media such as audio cassettes, videos, radio broadcasts and computer-assisted instruction. Unisa is currently experimenting with video conferencing, which will enable lecturers to conduct discussion groups from Pretoria.

This study introduces the medium of computer-assisted instruction for distance students in Statistics, in an attempt to provide an additional, supplementary learning resource and to provide practice, with immediate feedback.

### 2.3.2 Distance Education versus Mass Education

In considering distance education, one must be aware of the implications of mass education. The two concepts are not necessarily synonymous, as the following examples show.

One can create interactive learning episodes with few individuals who are geographically dispersed (distance, but not mass education). An example of this would be a course conducted via electronic mail and the Internet, whereby one could reach students far afield, but one would need to monitor and respond to individual mail messages, implying that a single instructor could not cope with large student numbers.

It is possible to reach large numbers of students in the traditional face-to-face lecture situation. An example of this situation would be a university lecturer delivering a lecture to a large hall filled with, say 400 students, or a speaker at a conference delivering a paper to a similarly large audience. These are examples of mass education, but not distance education.

And of course, one can have **both** distance and mass education, as in the case of say, a commercial bank wishing to broadcast training via satellite, to thousands of employees, countrywide.

The important implication of distance and/or mass education, is that it is the **number of students** that impacts on both the quality and amount of interaction possible, as well as on the cost effectiveness of developing and delivering the learning material (Henry, 1994).

In South Africa today, both the issues of increasing student numbers and decreasing funding are particularly pertinent. Traditional teaching methods cannot produce enough educated persons fast enough, especially in the sciences and other technologically oriented fields (du Plooy & de Villiers, 1992). These authors also highlight the fact that in recent years, tertiary institutions have been faced with perennial staff shortages and ever-growing student numbers.

It was as a result of such dilemmas that the introduction of electronic as well as traditional media has been investigated in various departments at Unisa.

## 2.4 Media selection

### 2.4.1 Multi media

The term **"multimedia"** (one word) has come to represent the combination of several media, such as graphics, animation, sound, video and perhaps CD-ROM, usually under the control of a computer programme. In this report, the term **"multi media"** (two words), in the sense of **"multiple media",** will be used. It refers to a model of instruction which combines several media which complement and supplement each other, not necessarily under the control of a computer programme.

The diagram on the following page shows an example of such a "multi media" approach.

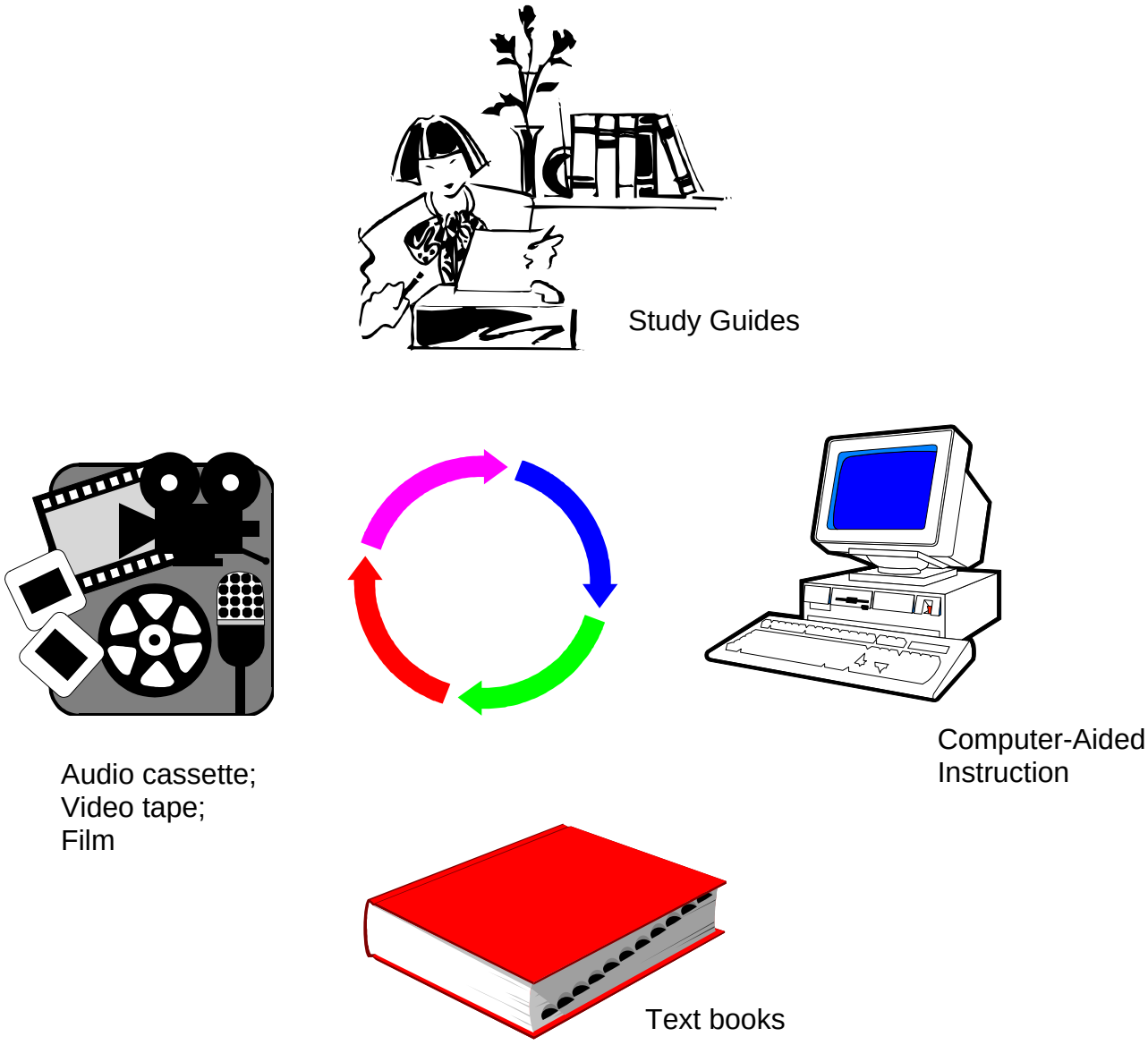



**Figure 2.6 Instructional model using "multi media" in the sense of "multiple media"**

This study uses the term **multi media** in the sense depicted in the above diagram, namely the combination of multiple media to supplement and enhance the learning process.

Romiszowski (1988) stresses the importance of selecting media and methods which are appropriate for the learning task:

> *"The multi media package adopts several presentation media, not so much to add variety to the lesson (though this itself is valuable) but because analysis of the subject and field testing has indicated that a particular method and medium ensures efficient learning of a particular concept or task"* (Romiszowski, 1988, p. 251).

In considering various teaching and learning media and their effects on the learning process, we need to clarify the concepts of media and method and to consider whether the introduction of a variety of media will, in fact, improve the learning that takes place.

### 2.4.2 The "Method versus Media" debate

What is a "method" and what is a "medium"? How do we define these concepts? How do we separate the two notions, and indeed should we try to separate them?

Clark (1991) defines a **method** as follows:

> *"An instructional method is any way to shape information that compensates for or supplants the cognitive processes necessary for achievement or motivation"* (Clark, 1991, p.35).

Most authors shy away from trying to define and/or classify **media**, which Laurillard (1993) describes as *"a notoriously difficult task"* (p.99). For our own purposes, let us accept the everyday definition of a "medium" as a "means of communication" (Oxford dictionary) - the way in which an instruction or message is delivered. The medium, then, is the physical object or person delivering the message.

In order to crystallise our understanding of the concepts of **method** and **media**, the following table describes these concepts and provides examples of each:

| **METHOD** | |
|---|---|
| **Description** | **Examples** |
| the instructional strategy;<br>the teaching approach;<br>the "design". | lecture;<br>discussion;<br>question and answer;<br>demonstration;<br>discovery;<br>experimentation;<br>role play etc. |
| **MEDIUM** | |
| **Description** | **Examples** |
| the technology;<br>the delivery mechanism. | text book;<br>overhead projector;<br>audio cassette;<br>video tape;<br>television;<br>electronic mail;<br>computer;<br>human voice etc. |

**Table 2.1 Matrix describing the essence of "method" and "media"**

In 1983, Richard Clark sparked a debate which continues today (Clark, 1983), by claiming that *"there are no learning benefits to be gained from employing any specific medium to deliver instruction"* (p.445). He used the now famous analogy that *"media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition"* (p.445).

Clark's long-time opponent in this debate is Robert Kozma, who is not convinced that the effectiveness of learning is not influenced by the media used. He is not so much an opponent in the debate, in that he recognises that Clark's viewpoint is a sober reminder that *"the mere introduction of computers will not improve learning. Method or design plays a significant role"* (Kozma, 1987, p.20).

In revisiting the debate this decade, Kozma therefore reframes the question as *"will media influence learning?"* (Kozma, 1994, p.7). In his article focusing on the role of computers in education, he asks *"Do computers have a unique set of capabilities among media and, if so, can these capabilities enable us to improve our designs and increase learning?"* (Kozma, 1987, p.20).

It seems clear from the work of both Clark and Kozma, that the method, or design, or instructional strategy built into the learning experience plays a significant role. So, too, does the choice of a medium appropriate for the attainment of learning objectives and desired learning outcomes.

Some of the misconceptions and misrepresentations surrounding this debate may stem from the fact that, when designing media effects experiments, researchers tend to confound the respective effects of **method** and **media,** thus sacrificing external validity. (Ross, 1994; Clark, 1994; Kozma, 1994). Kozma (1994) criticises Clark's attempts to separate media from method by saying that such a separation *"creates an unnecessary and undesirable schism between the two"* (p. 16). He goes on to make another discussion-provoking statement:

> *"If media are going to influence learning, method **must** be confounded with medium. Media must be designed to give us powerful new methods, and our methods must take appropriate advantage of a medium's capabilities"* (Kozma, 1994, p.16).

It is the opinion of the writer that **method** and **media** are inextricably woven into the fabric of the educational context in a symbiotic relationship that can not, and should

not, be torn apart. This three-way relationship is represented diagrammatically in Figure 2.7.

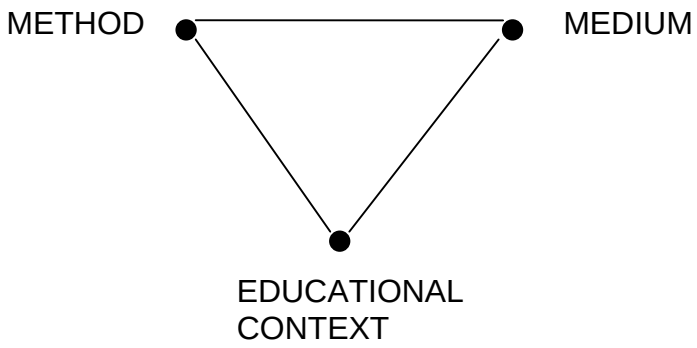



**Figure 2.7 The fabric of the learning situation**

The designer and the design process should be concerned with creating dynamic, creative interactions to address the above interrelationships. The application of media and their contribution to learning must be **designed** into complex social and cultural environments, something which traditional models of instructional design seldom do (Kozma, 1994). Kozma further states that *"An understanding of the way that media capabilities, instructional methods, and cognitive processes interact in complex social situations will allow us to take advantages of these capabilities"* (Kozma, 1994, p.17).

The cognitive processes and social situations mentioned above are an integral part of the learning process. Individual differences, such as motivation, learning styles, prior knowledge and experience and social pressures all play a part in contributing to the stuff of which effective and enjoyable learning experiences are made.

Our previous triangle of interrelationships can be modified to represent a more intricate tapestry of methods and media as follows:

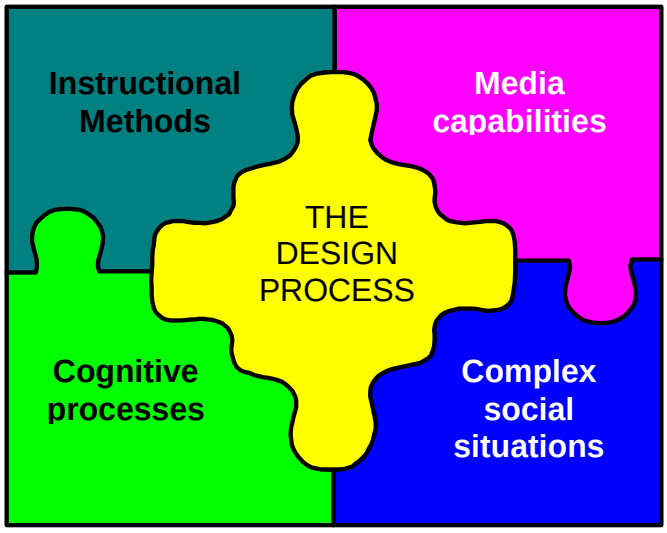



**Figure 2.8 The design process**

What implications does this debate have for distance learning? Just as was stated in section 2.3.2 above (traditional teaching **methods** cannot produce enough educated persons fast enough), so too is there a growing realisation that traditional teaching **media,** especially in the distance situation, cannot attempt to counter problems of isolation and lack of interactivity for the off-campus student.

The nature of distance education, where educational communication is mediated through technology across distance, is such that distance education professionals need to acquire new skills and competencies in order to expand their use of a variety of educational methods and media.

## 2.5 Computer-Assisted Instruction (CAI)

### 2.5.1 Modes of CAI

Alessi & Trollip (1991) propose various modes, or major types of computer-assisted instruction, which are summarised in Table 2.2.

| MODE | DESCRIPTION |
|---|---|
| Tutorials | Tutorials typically present information and guide the learner in the acquisition and application of knowledge. |
| Drills | Drills require the student to practise previously learnt concepts or techniques for fluency and retention. |
| Simulations | Simulations teach about some aspect of the real world by imitating or replicating it. |
| Games | Games provide an environment that facilitates learning or the acquisition of skills. |
| Tests | Computers can be used as an aid to construct the test and to administer the test. Computers can be used to generate, print and score both off-line and on-line tests. |

**Table 2.2 Modes of Computer-Assisted Instruction**

This study focuses on the first of the modes described in the above table, namely the use of computer-assisted tutorials (CATs) in the teaching of Statistics via distance education.

In using the term “tutorial”, the distinction must be made between the understanding of the term in the natural sciences, and the understanding of the term in the context of instructional design.

In the natural sciences, a “tutorial session” or a “tutorial group” is a small group of students, led by a tutor, who work through a set of practical problems with a view to practising the application of certain concepts presented during lectures.

In the field of computer-assisted instruction, the term “tutorial” means an interactive episode between a learner and the software. This tutorial process is epitomised by the ancient Greek idea of the Socratic dialogue - an approach of arriving at the truth

by asking and answering questions (Laurillard, 1993; Fresen, 1992). Laurillard's perspective on teaching and learning sees the process as *"inescapably and essentially a dialogue"* (Laurillard, 1993, p.97). Using the computer in the tutorial mode attempts to emulate this Socratic approach by posing frequent short questions and by giving immediate specific feedback to the student's response.

The main function of a CAI tutorial, then, is to present instructional material and to guide the learner through the initial use of the information or skills (Alessi & Trollip, 1991). Extended practice and assessment are the domain of other CAI modes, such as drills and tests.

### 2.5.2 Using computers in teaching Statistics

How can we use the personal computer to develop Statistics instruction for future statisticians and researchers in related fields?

The Computers in Teaching Initiative (CTI) in Britain was established in 1985 and is working to overcome the inertia in teaching methods often encountered in universities today. Their Annual Report (1991/1992) states:

> *"There is a growing realisation throughout higher education that learning technology is not a passing fashion, but something that will be playing a steadily increasing role in education at all levels"* (Computers in Teaching Initiative, 1991/1992, p.5).

The CTI has established 20 subject-specific Centres throughout Britain. Each Centre combines a thorough understanding of the teaching needs of its discipline with expertise in computer based teaching and learning techniques. The Centre for Mathematics and Statistics is based at the University of Birmingham with co-directors Dr Mike Beilby and Dr Adrian Bowman (Glasgow). This Centre offers regular workshops, maintains a database of software packages and produces a quarterly

newsletter *Maths & Stats*, as well as the *Guide to Software for Teaching* (Computers in Teaching Initiative, 1991/2).

Bishop, Beilby and Bowman (1992) of the above Centre outline the work of the Centre and give an overview of the courseware contained in their database. The category of Statistics courseware contains 50 packages and the authors make the point that *"in all cases, teaching material needs to be written to enable students to use these packages effectively"* (Bishop et al, 1992, p.136).

This statement reinforces the argument put forward in this chapter that the indiscriminate use of statistical packages, without understanding the underlying concepts is unwise. The computer can be used in the teaching of Statistics as an educational tool to teach statisticians about the tools of their trade.

Prybutok, Bajgier and Atkinson (1991) describe several examples of classroom exercises that simultaneously utilise the capabilities of the computer and the instructor to enhance the teaching of concepts in a Statistics course. They anticipate that Statistics instruction of the future will make increasing use of interactive graphical software specifically designed for use in the teaching of Statistics.

These authors envision a statistics 'laboratory' as part of the traditional classroom setting, which will provide hands-on experience and practice for students:

> *"In the setting we propose, the microcomputer is the medium in which experiments are conducted to help us achieve our pedagogical objectives"* (Prybutok et al., p.16).

These authors use various software packages that are particularly useful in illustrating concepts and motivating discussion on those concepts. The lecturer and students engage in a dialogue which motivates students to think about the underlying statistical concepts. Such sessions can be thought of as "laboratory-lecture" sessions, which augment the traditional lecture approach.

Scotney and McLean (1995) designed, developed, implemented and evaluated a suite of hypertext CBTs concerned with descriptive Statistics, introductory data analysis, questionnaire coding and analysis. The CATs are structured to meet three primary objectives: the introduction of concepts, the facilitation of revision, and the acquisition of skills. Not only do they use the traditional CAI tutorial approach, but they make reference to the statistical package *Minitab*. They incorporate output from *Minitab* into the CATs, with 'pop-up windows' and hotspots offering explanatory explanations. These CATs aim

> *"to provide students with an intuitive understanding of statistical concepts and a variety of relevant examples are used to illustrate the techniques"* (Scotney & McClean, 1995, p.84).

In order to facilitate independent learning, the CBTs were accompanied by a paper-based booklet which explained the essential features of the system.

This project has parallels with the present study, in the use of CBTs, together with supporting paper-based material, as well as the effort to encourage deeper understanding of abstract statistical concepts. It also makes a start in trying to meet the need for statisticians trained in the use and interpretation of statistical methods and statistical packages.

### 2.5.3 How effective is CAI?

How effective is CAI? Is CAI a medium, or a method or a combination of both?

In the 1980s, a couple who were at that time at the University of Michigan, published several meta-analyses of media research (Kulik, Kulik & Cohen, 1980; Kulik & Kulik, 1986, and others). They claimed that computer-based education (CBE) made small but significant positive contributions to the course achievement of college students.

However, in the light of the Clark-Kozma debate on whether media contribute to the quality of learning (see section 2.4.2), we need to consider whether in the case of CAI, it is the medium of the computer, or the built-in design techniques that contribute to effective learning.

Clark picked up the claims made by the Kuliks and considered "What is the Matta with Meta Analyses?" (Clark, 1991). He stated that:

> *"After a number of arguments, Jim (Kulik) agreed with me that it is not the computer but the teaching method built into CBI that accounts for the learning gains in those studies. More importantly, he agreed that the methods used in CBI can be and are used by teachers in live instruction"* (Clark, 1991, p.36).

Usually another problem with meta-analyses is the publication bias. Only studies that show some measurable effects are considered worth publishing - studies which show no significant differences between various treatments are usually not published.

A meta-analysis that supports Clark's point of view was carried out by Thomas Russell (1995) and is published on the Internet. He extracted the results from 214 research reports, summaries and papers, all of which came to the same conclusion of "no significant differences". Schlosser and Anderson (cited in Russell, 1995) stated that

> *"... students learn equally well from lessons delivered with any medium, face-to-face or at a distance... hundreds of media comparison studies indicated, unequivocally, that there is no inherent significant difference in the educational effectiveness of media...".*

At the same site on the Internet is a response by Bill Orr, which cites 62 studies in which the authors believe that they have shown the efficacy of new interactive media during recent years. Orr comments, however that he doubts whether learning gains

can be measured: *"I do not believe the field of education to be amenable to quantitative tools and statistics..."* (Orr, 1996).

What is a sensible and practical point of view to adopt in the face of apparently conflicting research results?

Computers are in the process of transforming every human endeavour, but sadly, in education, this trend very often lags behind. Kulik and Kulik (1986) describe this innovation in education as being of similar significance as the invention of the printing press in the 15th century and the invention of writing itself thousands of years ago. Computers are slowly finding a place in the classroom in some schools and universities in South Africa, where they can be used as powerful tools by teachers and learners alike. The technological revolution of the latter half of the 20th century is well entrenched.

Computer-assisted tutorials (CATs) are appropriate for presenting factual information (such as definitions and theorems in Statistics) and when intellectual skills such as concepts, rules and procedures are to be learnt (Alessi & Trollip, 1991). These authors also maintain that CATs are useful for learning problem-solving strategies. It is precisely the presentation and explanation of statistical concepts and principles that have been identified, by the argument built up in this chapter, as critical areas in training future statisticians and researchers.

In particular, in the distance education setting, computer-assisted tutorials offer the student the experience of multi media (in the sense of multiple media), increased interaction with learning materials, and a decreased sense of isolation (de Villiers, Pistorius, Alexander & du Plooy, 1992).

Kapoor and Lakhanpal (1990), citing Levien, make the point that *"CAI brings the individual into the learning process in an active manner that facilitates learning"* (p.164). Even if we cannot necessarily accept such a statement as proof that learning is facilitated, it is clear that, especially in distance education, CAI does

involve the individual in the learning process in an active manner. Even if it is still at a distance, and even if it is as an individual rather than as part of a co-operative learning group, CAI can offer the student an additional learning experience. Scotney and McClean (1995) describe the design, production and implementation of a suite of hypertext CATs concerned with teaching descriptive statistics. They claim that

> *"Computer-based tutorials (CBTs) offer the potential for improved learning efficiency, teaching efficiency and flexibility"* (Scotney & McClean, 1995, p. 80)

and

> *"Computer Based Learning (CBL) is most cost effective in higher education institutions in situations where large numbers of students study courses which have elements such as research methods in common"* (Scotney & McClean, 1995, p. 80).

In their particular project, they found that over 80% of the students found the CBTs satisfactory or better in terms of organisation of material, screen presentation, ease of use and use as a revision aid (Scotney & McClean, 1995).

CAI offers the facility for immediate and individualised feedback, which is usually lacking for the off-campus student (perhaps also for many on-campus students). The opportunity for hands-on practice in applying statistical techniques is vital in training statisticians and researchers to solve real-world problems. In the case of distance education, computer-assisted tutorials can go some way in replacing tutorial group sessions that are usually held in the natural sciences at residential universities. More than that, computer-assisted tutorials can be designed to present statistical theory in a novel and enticing way, so as to encourage a deeper intuitive understanding of the subject matter, so vital to cognitive theorists in promoting the active use of knowledge

in the real world. This will, of course, depend on the creativity of the educators and the extent of their computer skills.

In the face of the debates and sometimes conflicting research evidence, let us synthesise the various viewpoints into underlying assumptions which will form the basis of this research report.

**Underlying assumptions**

- Let us accept that, difficult as it is to measure the effectiveness of CAI (Kulik et al, 1980; Russell, 1995; Orr, 1996), educationists need to continue to explore the potential and effectiveness of the computer as a learning medium.
- Let us decide that when considering the benefits of CAI, we understand them to be perceived benefits rather than proven benefits (Orr, 1996).
- Let us understand that CAI is an inseparable marriage of method and medium (Kozma, 1994). It is not important whether it is the medium or the method that contributes to learning, as long as learning gains are evident.

Let us consider each case on its own merits and let us continue to pursue the effective use of computers in education.

## 2.6 Summary

In modern society, the increase in knowledge rests largely on scientific research. The scientific method involves the design of experiments, the collection of data, the analysis of the data and the interpretation of the data. In order to arrive at valid conclusions, researchers need to understand the underlying principles and assumptions on which statistical methods are based.

Studies recorded to date have concentrated on the intersection of two of three areas, namely CAI in Statistics education, or CAI in distance education, or Statistics via distance education. This study considers the intersection of all three areas, namely the design, development, implementation and evaluation of computer-assisted tutorials in teaching Statistics via distance education, as shown in Figure 2.9.

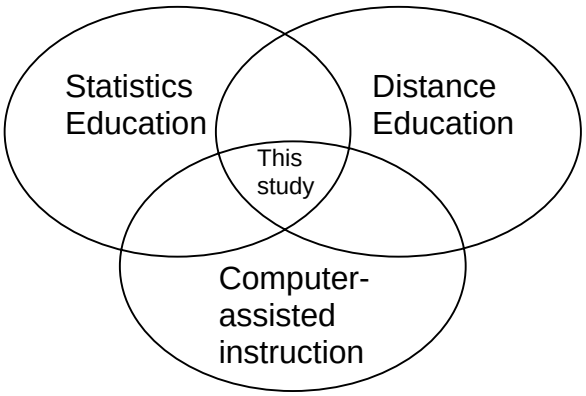



**Figure 2.9 The placement of this study**

The above figure shows the merging of the three areas concerned. Computer-assisted instruction, in particular computer-assisted tutorials, is a medium well suited to the presentation and demonstration of statistical concepts and principles. CAI tutorials also offer the opportunity for interaction and practice, so necessary for the student studying at a distance.

# CHAPTER 3

# *INSTRUCTIONAL DESIGN*

# *FOR "RANDOM VARIABLES"*

## 3.1 Introduction

The history of the University of South Africa (Unisa) dates back to the establishment of the University of the Cape of Good Hope in 1873. It was initially an examining and not a teaching university, with which several teaching colleges were affiliated. In 1916 this institution became known as the University of South Africa. At this time, the affiliated Victoria College and South African College became respectively the University of Stellenbosch and the University of Cape Town. In 1946 Unisa was officially established as a distance teaching university.

Unisa caters for the student unable to attend a residential university - the community-bound student. There are also those students who prefer to pace themselves and to study independently. Unisa is one of the largest universities in the world and offers distance teaching up to doctoral level in a wide variety of disciplines (Unisa, 1993/ 1994).

According to Holmberg (1989), distance education is education which is not under the continuous, day-to-day supervision of tutors in face-to-face tuition sessions, but which does offer the planning, guidance and support of an organisation.

Unisa strives to take the "distance" out of distance education by promoting what Holmberg (1989) calls a *"guided didactic dialogue"* (p.22). In line with this approach, Unisa has established learning centres regionally where students can benefit from contact with tutors and peers. The slogan of the learning centres is *"Taking the distance out of distance education - a responsive and integrated approach to learner support"* (Poster at Unisa).

The dominant medium is print: study guides and tutorial letters form the main components of a typical study package. Other media are increasingly being integrated into this package: audio cassettes, Radio Unisa, teleconferencing, videos and computer-assisted learning. In 1995, Unisa introduced 'Students-on-line', a service whereby students who have access to a computer and a modem are able to communicate with their lecturers via e-mail and access their results and the library electronically.

Examinations are held in over 450 centres throughout Southern Africa, Africa and overseas. Unisa envisages that the advantages of distance education will enable the University to respond to the increasing demand for tertiary education (Unisa, 1993/1994).

## 3.2 Rationale for the development of "Random Variables"

In line with Unisa's policy of taking the distance out of distance education, the Department of Statistics at Unisa decided in 1994 to investigate the use of computer-assisted instruction.

Statistics is a subject which lends itself to computer-assisted learning. It has a core of fundamental concepts and techniques which to a large extent are common across institutions and curricula, thus affording the potential for sharing resources and learning materials. It is a subject particularly suited to graphical representation - indeed the graphical representation of data is at the heart of the subject. Statistics is a subject that is

> *"studied and understood by explorations that are numerical and algebraic. The computer can take the role of informer, illustrator and experimental tool"* (Bishop, Beilby & Bowman, 1992, p.131).

In the same vein, du Plooy and de Villiers point out that

> *"computer science lends itself to animation, simulation, and improved ways of presentation to students, which makes it an ideal subject to teach via CAI"* (du Plooy & de Villiers, 1992, p. 10).

The same can be said of Statistics as an academic discipline, which involves both the presentation of theory, and the need for the student to apply the theory in the solution of practical problems. Not only does the student need practice in problem solving, but he or she also requires immediate feedback to reinforce correct answers and to remediate incorrect responses. Such interaction is particularly difficult to achieve in a distance education scenario, unless one turns to the computer as a supplementary learning medium.

In 1994 the author was approached by the Department of Statistics at Unisa and asked to design and develop computer-assisted tutorials (CATs) to supplement the study-guide for the first year statistics module, STA101-H. Her background in Mathematics, Statistics, Education, as well as computer-assisted education meant that it was possible for her to tackle both the design and the development of the CATs required.

In line with the research done at Unisa by de Villiers, Pistorius, Alexander and du Plooy (1992), the Department of Statistics agreed with two points in particular:

1. CAI should be used as a supplementary resource, to be augmented by and supportive of the traditional written word and other appropriate media. In view of this, CAI is never a solution on its own, nor does it replace study guides, text books and contact with the lecturer.

This multiple media approach is illustrated in the diagram below:

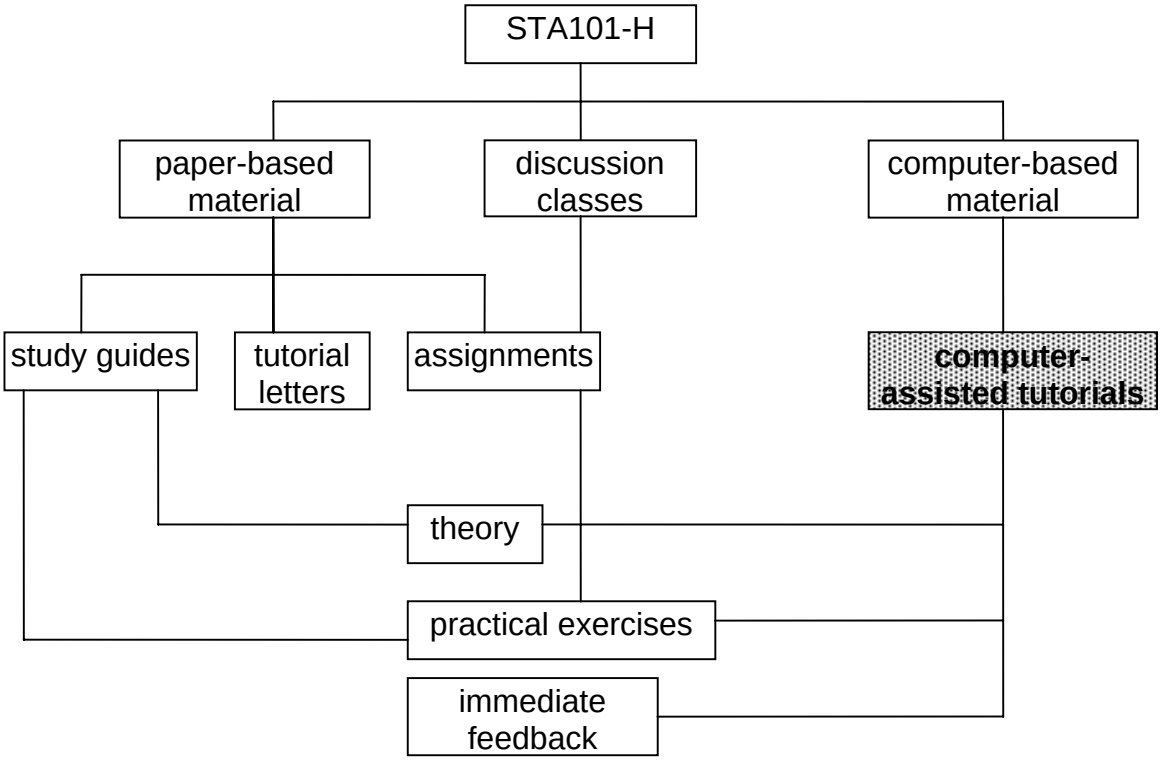



**Figure 3.1 Study package for STA101-H at Unisa**

2. The design and development of customised CAI is most successful when undertaken by a team, consisting of at least subject matter experts, instructional designers, programmers and graphic artists (Alessi & Trollip, 1991; de Villiers et al, 1992; Kontos, 1984; Faiola, 1989). In this project the courseware development team was made up as follows:

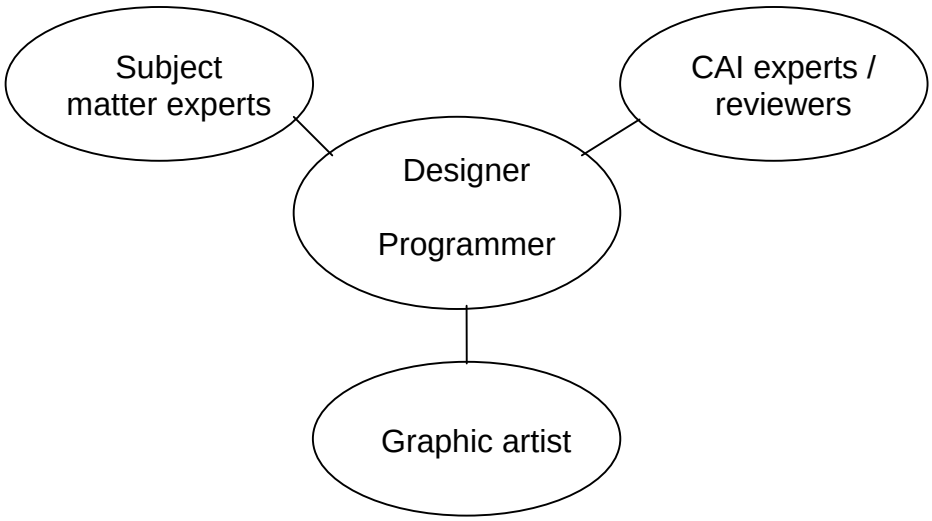



**Figure 3.2 Composition of the courseware development team**

## 3.3 Instructional design process

### 3.3.1 Theoretical model

Various different models of the instructional design process have been proposed (Alessi & Trollip, 1991; Lee & Mamone, 1995; Main, 1993). The theoretical framework used as a basis for this study is represented diagrammatically by Hodgkinson's "Daisy Model" shown below:

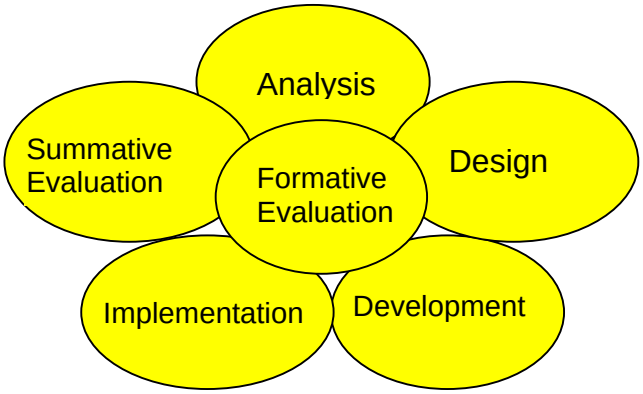



**Figure 3.3 The "Daisy Model" of the instructional design process (Hodgkinson, 1996)**

Starting with analysis, the instructional design process is cyclical and ongoing. Formative evaluation is at the centre, since it is revisited at various stages, in polishing and refining the product. Formative evaluation thus has an impact on all stages of the instructional design process.

This theoretical model was adapted for use in this study, with different emphases being accorded the various "petals", as discussed in the next section.

### 3.3.2 Adaptation of the theoretical model

This study follows the path of the analysis, design and development of customised CATs for the Department of Statistics. It emphasises the formative evaluation that took place at each stage in the cycle. It does not consider summative evaluation, which constitutes a topic for further research. Therefore the summative evaluation petal has been removed in Figure 3.4 below, and the sizes of the remaining petals indicate the relative extent of each stage .

In "zooming in" to the formative evaluation stage of the "Daisy Model", we define the following micro-stages, which show how formative evaluation was operationalised throughout the process.

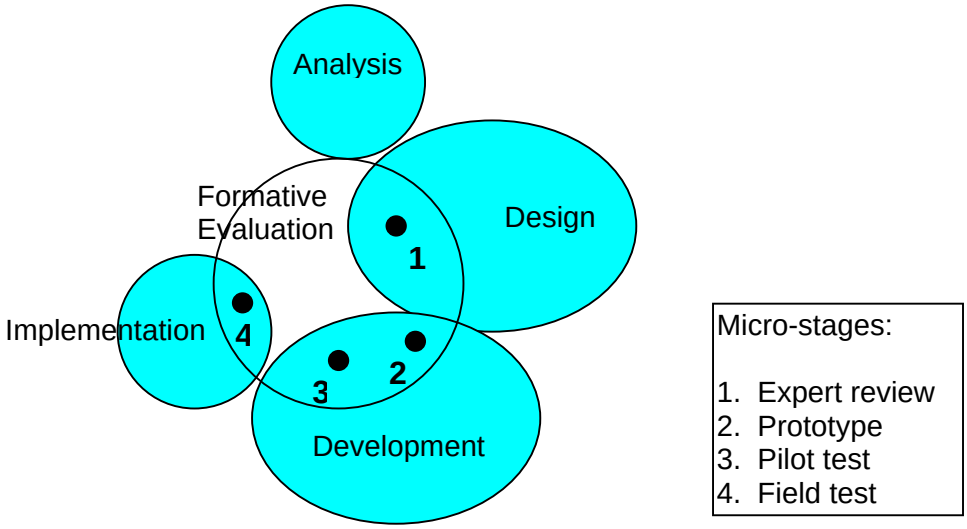



**Figure 3.4 Adaptation of the theoretical model**

The four micro-stages in this adapted model are discussed in detail in Chapter 4 (Research Methodology).

The remainder of this chapter discusses the main stages of instructional design, with respect to this study, namely formative evaluation, analysis, design, development and implementation. We start with formative evaluation in general, since it affects

each part of any instructional design model. In fact, Reeves (1993a) calls formative evaluation *"the essential lifeblood of the instructional development process"* (p.15.11).

## 3.4 Formative evaluation

Beyer defines formative evaluation as follows:

> *"Formative evaluation, simply put, means evaluating or assessing a product* ***while*** *that product is in the process of being created and shaped"* (Beyer, 1995, p.7),

and he points out that

> *"formative evaluation is* ***ongoing*** *in that it occurs repeatedly, at various stages throughout the development process, from the design or platform stage through the prototype (draft), pilot, and field trial stages of the product"* (Beyer, 1995, p.7).

It can be seen that the four micro-stages

1) expert review
2) prototype
3) pilot test
4) field test

in the instructional design model for this study (Figure 3.4) are modeled on those mentioned above by Beyer (1995).

According to van Niekerk (1995, p.103), *"formative evaluation refers to the evaluation of the instructional process while it is being carried out with the aim of improving or changing the course."* A function of formative evaluation is to determine whether the instruction really helped the student to achieve learning objectives. Van Niekerk goes on to list the characteristics of formative evaluation:

*"Formative evaluation*

- *is usually done by the course writer;*
- *is usually not a large-scale effort;*
- *may or may not be costly;*
- *often uses descriptive statistics;*
- *is driven by decision-making and operational constraints of the organisation;*
  *and*
- *relies heavily on monitoring and performance indicators of short-term effects"*

Van Niekerk (1995, pp.103-104).

Van Niekerk also maintains that formative evaluation should be a regular and integral component of the course design process.

## 3.5 Analysis

### 3.5.1 Target population analysis

Unisa has a long-standing tradition of providing education to disadvantaged students. These may be students

> *"who have neither the means nor the opportunity to attend a residential university: women at home, older people wishing to make their retirement more meaningful, men and women who wish to make a career change but do not have the required academic background to do so, and even people in prison and youngsters doing military service"*
> (du Plooy & de Villiers, 1992, p. 7).

In 1995 Unisa's student body numbered approximately 128 000 (Unisa, 1995). Male and female students are represented in almost equal proportions. The average age is 32 years, ranging from 17 to 84. In 1995 the home language distribution of Unisa students was as follows:

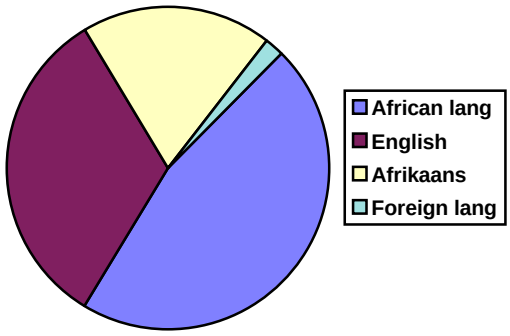



**Figure 3.5 Language distribution of Unisa students in 1995**

Geographically, the majority of Unisa's students reside in the Republic of South Africa, with approximately 3760 students in the rest of Africa. There are also about 1200 students in overseas countries.

As de Villiers (1993) reports, Unisa students are heterogeneous with respect to race, language and academic background.

The subjects of this particular study include both male and female post-secondary students studying Statistics at first-year level in the Faculty of Science at Unisa. Approximately 400 students register for STA101-H each year, with around 300 writing the final examination. Although the entrance requirement for this course is matriculation mathematics, the students exhibit a wide spread of existing mathematical ability and prior knowledge. This is a common problem in adult education and is

> *"exacerbated in a society with a mixture of first-world and third-world students and a very uneven standard of high school education"* (Alexander, Pistorius, du Plooy & de Villiers, 1992, p.19).

Particular care, therefore had to be taken in the design of the CATs required by the Department of Statistics. Cultural, language and age differences had to be taken into account. For example, when using examples such as tossing a die, or selecting a card from a pack of playing cards, the option had to be provided for the student to access further information on these activities, with which they may or may not be familiar.


**Figure 3.6 Example of a pop-up help window from the tutorial on Probability**

Isaacs (1990) comments that the use of 'pop-up' dialogue boxes and windows is an attractive method for making comments or offering help without disrupting the screen display. This feature also offers an additional degree of student control in that the help pop-up window is readily available for those students who choose to access it.

### 3.5.2 Subject matter analysis

The content of the course is well-defined and clearly laid out in the study guide for STA101-H. The intention was that the content of the CATs should closely mirror that in the study guide and should make use of the same conventions with respect to statistical notation. The CATs needed to supplement and reinforce the content in the study guide, without becoming "*electronic page-turners*" (Delpierre, 1991, p.63).

The author therefore used the structure of the study guide as a basic framework for the content. One (or more) CATs were designed and developed for each chapter in the guide. The topics within the chapter became the choices on the Main Menu in the CAT. Sub-menus were introduced where necessary to subdivide the content into manageable "chunks", in order to increase the capacity of short-term memory (Kozma, 1987). The Main Menu and a sub-menu are shown in Figures 3.7 and 3.8.

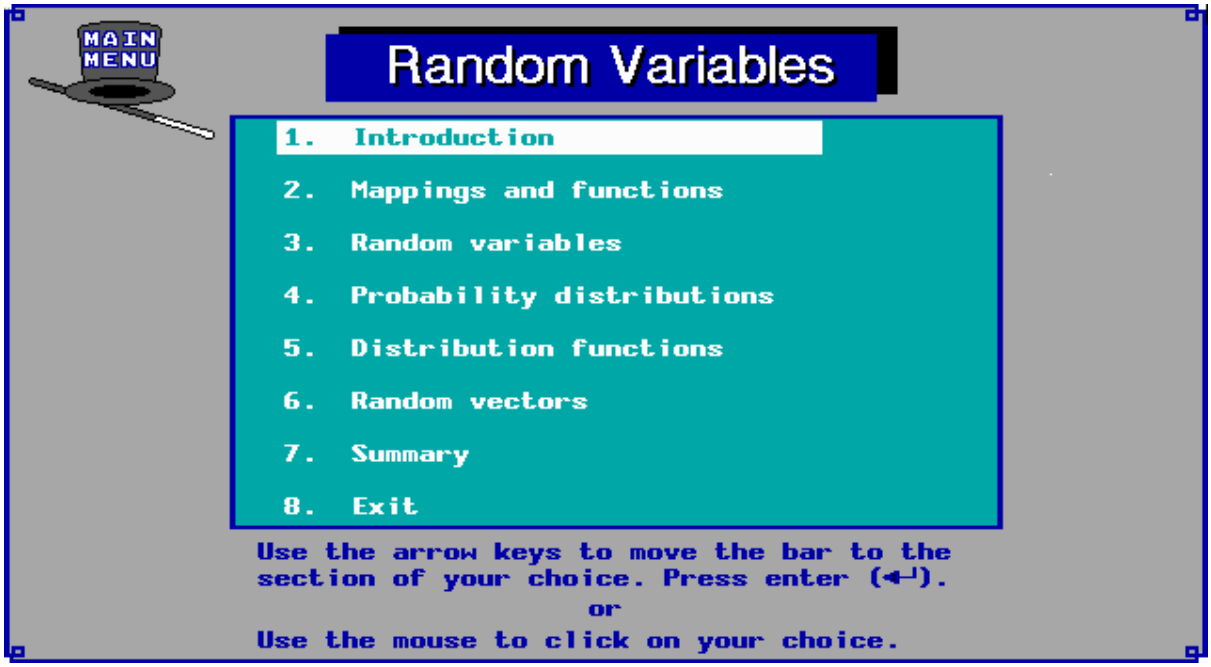



**Figure 3.7 The Main Menu**

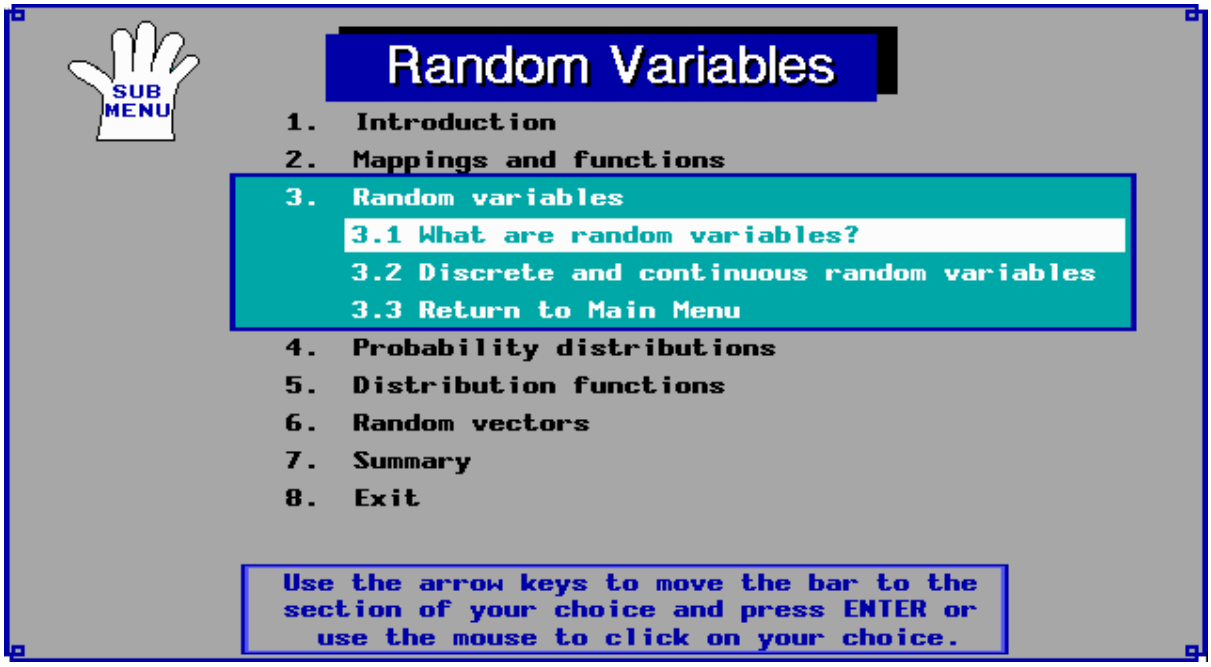



**Figure 3.8 A sub-menu**

In order to expand the subject matter and provide a variety of examples and exercises, the author consulted a variety of text books (Megeath, 1975; Mendenhall, 1990; Quirin, 1978; Steen, 1982; Triola, 1980). She also consulted various experienced subject matter experts (Fresen, 1995; Jordaan, 1995; Debba 1995) in order to discover approaches and techniques that they had used successfully in teaching the abstract concepts inherent in the subject matter. This approach is elaborated further in section 3.6.1 (Instructional strategy).

### 3.5.3 Media analysis

In 1989 the Department of Computer Science and Information Systems at Unisa developed a "Computer Concepts" course using CAI as part of the study material (Alexander et al., 1992). The enthusiasts in that department established a centre of CAI expertise called CENSE, the Centre for Software Engineering. CENSE includes a team of designers, programmers, evaluators and a graphic artist. They also established project management structures, which have been successfully implemented in the distance education setting (Pistorius, de Villiers & Alexander, 1992).

> *"We were determined to produce high-quality courseware by planning properly and by following systematic design methods. Thorough preliminary planning was done before we finally set up a course in which a significant percentage of the tutorial package consisted of CAI courseware"* (Pistorius, du Plooy, Alexander & de Villiers, 1992, p.13).

It was clear that the material in the first year Statistics module, STA101-H lent itself to the medium of CAI, and in view of the success achieved by the above-mentioned team, there was little doubt that the same procedures and media would be desirable for this project.

### Hardware

Unisa has established micro-computer laboratories for the use of students in Pretoria, Cape Town, Durban and Pietersburg, so no financial outlay for hardware was necessary. Students are encouraged to purchase the computer-assisted tutorials on diskettes, which are sent to them through the post, so that they can work through them in their own time on their own computers. Alternatively they can make use of the regional computer laboratories at no charge.

This form of decentralised CAI imposes two immediate constraints (de Villiers et al., 1992). Firstly, because the students are using a wide variety of computer hardware in their homes or work places, many of which may be of fairly limited capacity, designers and developers need to be aware of the fact that animations may be frustratingly slow, the number of colours and screen resolution may not be adequate, and video and sound can generally not be considered. Secondly, since the computers are not linked to a network, record keeping and monitoring of students' progress is difficult to achieve. The Unisa teams are investigating downloading the

courseware and gathering performance data via a communication network (de Villiers et al., 1992), which should be more easily enabled today with the proliferation of e-mail and the Internet among the general population (Gates, 1995).

### Software

In selecting an authoring system, several aspects need to be considered. Alessi and Trollip (1991), classify classical computer programming languages, authoring languages and authoring systems on a continuum (see figure 3.9). Each extreme of the continuum offers different strengths and advantages, which need to be considered in the light of the needs of each individual development project as well as the resources available.

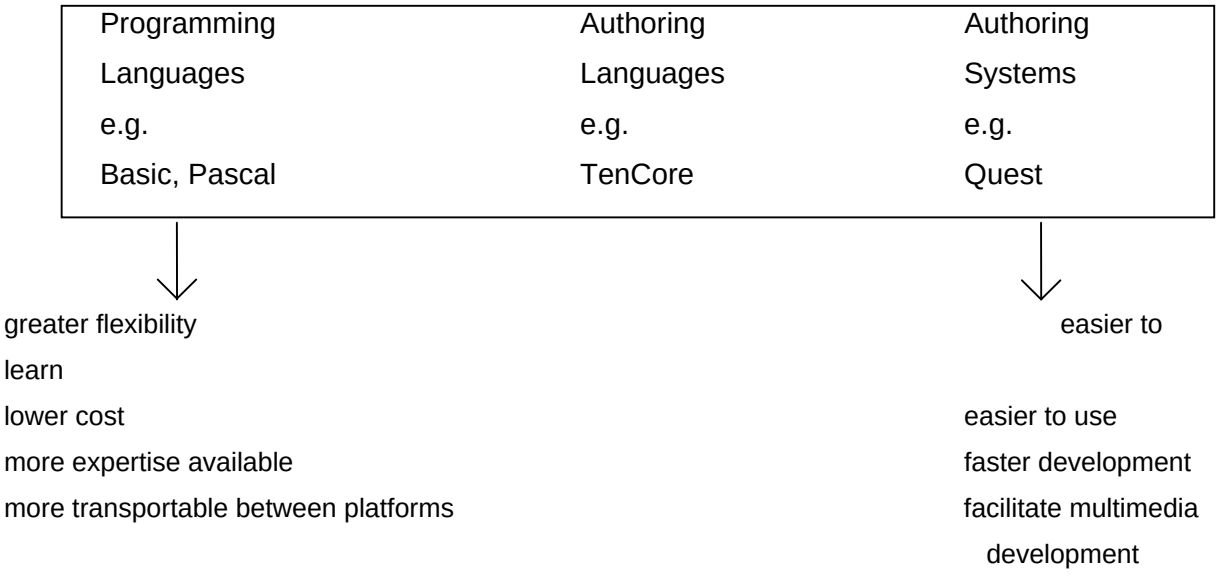



**Figure 3.9 Continuum of authoring systems**
**(Adapted from Alessi and Trollip, 1991, p.342)**

Authoring systems can be frame oriented (e.g. Quest), object oriented (e.g. Quest), event oriented (e.g. Authorware Professional) or code oriented (e.g. TenCore), each orientation offering various strengths and weaknesses.

Cronjé (1996) summarises authoring systems according to the categories shown in the following diagram:

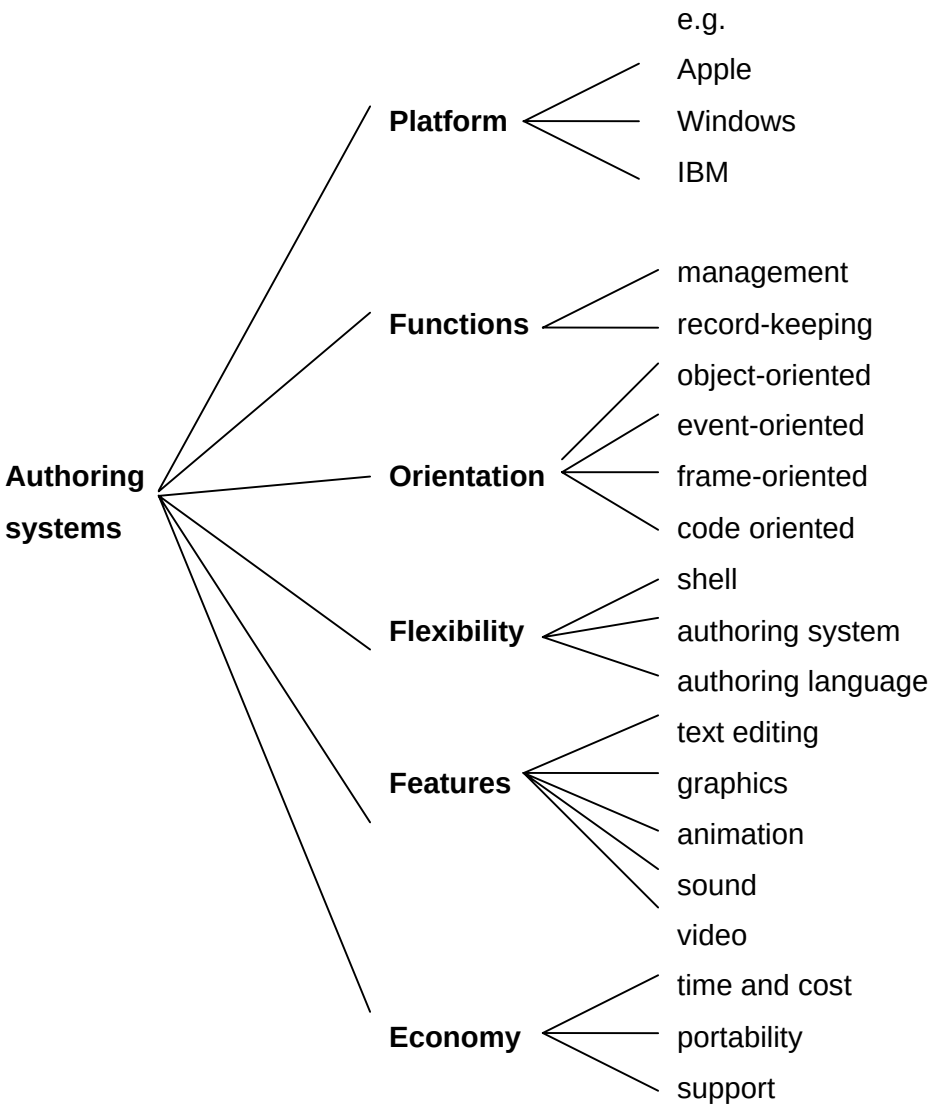



**Figure 3.10 Features to consider in the choice of an authoring system (Cronjé, 1996)**

The authoring software, TenCORE (Computer Teaching Corporation, 1993), was already in use by CENSE at Unisa, and the Department of Statistics was able to

make use of one of their licenses. TenCore is classified by Alessi & Trollip (1991) as a *"code-oriented authoring system",* which means that *"a substantial part of the development is programming of the classic type, writing lines of computer commands...".* TenCore is not one of the recent generation of object oriented authoring systems such as Quest (Allen Communication, 1994), which facilitate multimedia development.

The requirement of the Department of Statistics was for customised CATs, which closely mirrored the content covered by the study guide. This customisation required the programming of specialised statistical routines and response judging routines. Furthermore there were no immediate time constraints in producing the tutorials: therefore TenCore, with its greater degree of flexibility was thought to be a suitable choice of authoring system.

An example of a specialised question, where the student is required to key in the elements of a set, is given in Figure 3.11. Programming in TenCore allows the system to check for the correct elements, as well as the required number of semi-colons and to give appropriate feedback for various anticipated student responses.

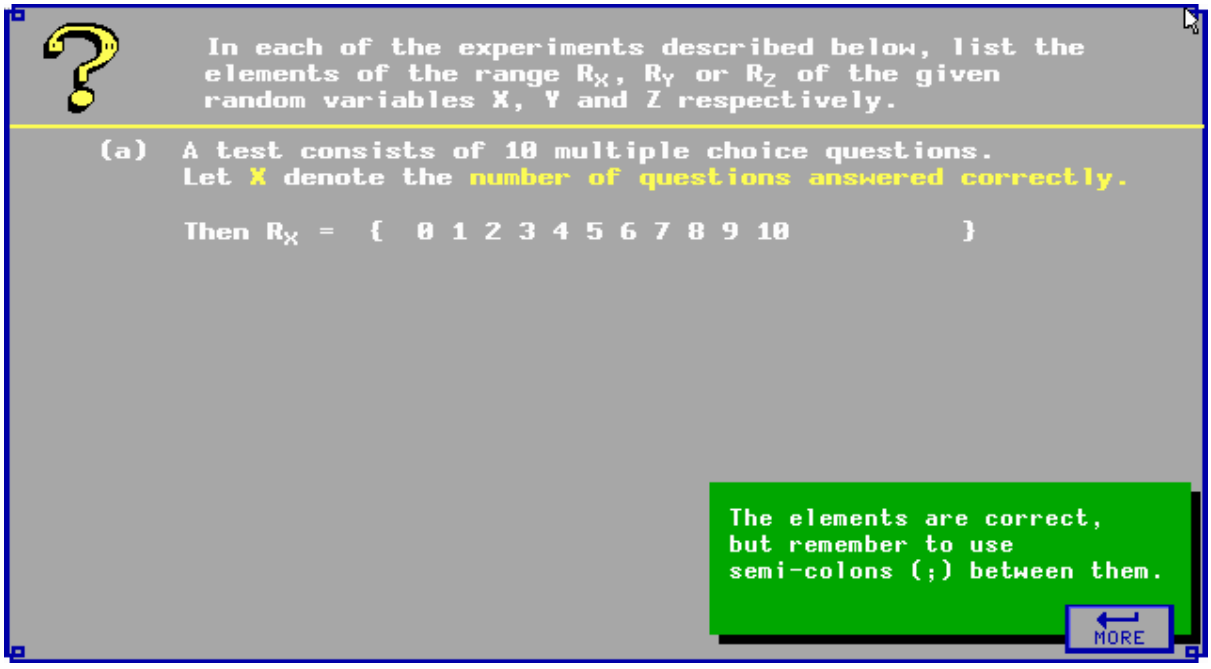



**Figure 3.11 Example of a specialised student response**

There was no immediate time constraints in producing the tutorials: therefore TenCore, with its greater degree of flexibility was thought to be a suitable choice of authoring system. Another feature in favour of TenCore is that the final CAT is produced as a single binary file, together with one fonts file and two system files can usually fit onto one high density diskette. This simplifies the production and distribution of diskettes to students studying at a distance and maintains costs at a minimum.

## 3.6 Design

### 3.6.1 Instructional strategy

In the distance learning situation, interaction for the student is generally limited. The student interacts with the information provided in the study guide, with limited written or telephonic contact with the lecturer. Assignments are submitted, but the student usually has to wait several weeks before obtaining feedback. There is little opportunity for cooperative learning or "*positive interdependence*" (Johnson and Johnson, 1991, p. 127) and exchange between students.

The subject of Statistics in particular, is generally presented in a very formal and distant way. Definitions, formulae and theorems are presented and the content is rather abstract and theoretical. The module STA101-H is the first exposure for Science students to the subject of Statistics. The study guide is content-based and tends to be rather stark and lacking in introductory and motivating material.

Thus the need was identified to make the content more meaningful and understandable to the students. It was clear that the CATs should not be electronic versions of the study guide, but should provide the "*cognitive strategies*" or "*instructional scaffolds*" (Rosenshine & Meister, 1992, p.26) necessary to encourage intuitive understanding of basic concepts.

Möller (1993) describes the ideal of imitating human interaction using electronic media:

> *"A good way to ensure concise, but very effective communication, is to compare the computer to that excellent instructor who explains, gives directions, exposes new knowledge in a structured manner, rather than to the excellent textbook or encyclopaedia"* (Möller, 1993, p.26).

The rationale behind the design of the tutorials therefore, is that they should encourage intuitive understanding of the underlying concepts, such as

> "What really is a random variable and how and why does it originate?"
> "What is a probability density function?"
> "How do we generate a probability density function?"
> "What does a probability density function look like and how can I remember what it is? "

How then did the author go about moulding and presenting the content for the instructional purposes of reducing cognitive load (Fleming & Levie, 1993) and enhancing basic understanding? The instructional strategy included the following features:

- the use of a theme character (white rabbit) to conduct a personal dialogue with the student (human-computer interaction: Jih & Reeves, 1992; Marchionini, 1992);
- the alternation of deductive (from the general to the particular) and inductive (from the particular to the general) approaches;
- the use of everyday examples, such as the number of children in a family, the distribution of marks in a test etc., so as to provide situated and meaningful learning experiences (Merrill, 1991; Reeves, 1993b);
- repetition of familiar examples and diagrams to reinforce understanding and enhance retention (Bangert-Drowns & Kozma, 1989);

- step-by-step build up of concepts ("chunking" - Kozma, 1987; Fleming & Levie, 1993; Faiola & DeBloois, 1988);
- colour coding and consistency (Faiola & DeBloois, 1988);
- textual, pictorial and other cues, such as arrows, labels, shading and highlighting (Beck, 1991);
- learner control in being able to access help windows, replay screens etc. as and when the individual student requires it (Caffarella, 1987);
- building on previously learned knowledge (Caffarella, 1987; Alessi & Trollip, 1991) that was acquired in the study guide and earlier CATs in the series;
- orientation information, such as headings on each presentation screen, and the "Where am I?" feature for the student to keep track of his progress through the material;
- the extensive use of graphics, to which the subject matter particularly lends itself, since pictures and diagrams are more memorable than words (Mayer & Gallini, 1990; Fleming & Levie, 1993);
- the use of animations to illustrate concepts and relationships in a manner that is not possible with the written word (Rieber, 1990).

Many of these features can be seen on the screen prints included in this chapter. An example of an animation routine is discussed below.

In the study of random variables, two of the key concepts are the creation of the probability density function (p.d.f.) and from this, the creation of the cumulative distribution function (c.d.f.). In order to strengthen the students' understanding of how the c.d.f. is generated from the p.d.f., a computer animation was used to illustrate this practically. The full impact of the animation can be seen by running the tutorial on the enclosed diskette. Figures 3.12a and 3.12b show the beginning of the sequence (the p.d.f.) and the final screen (the c.d.f.).

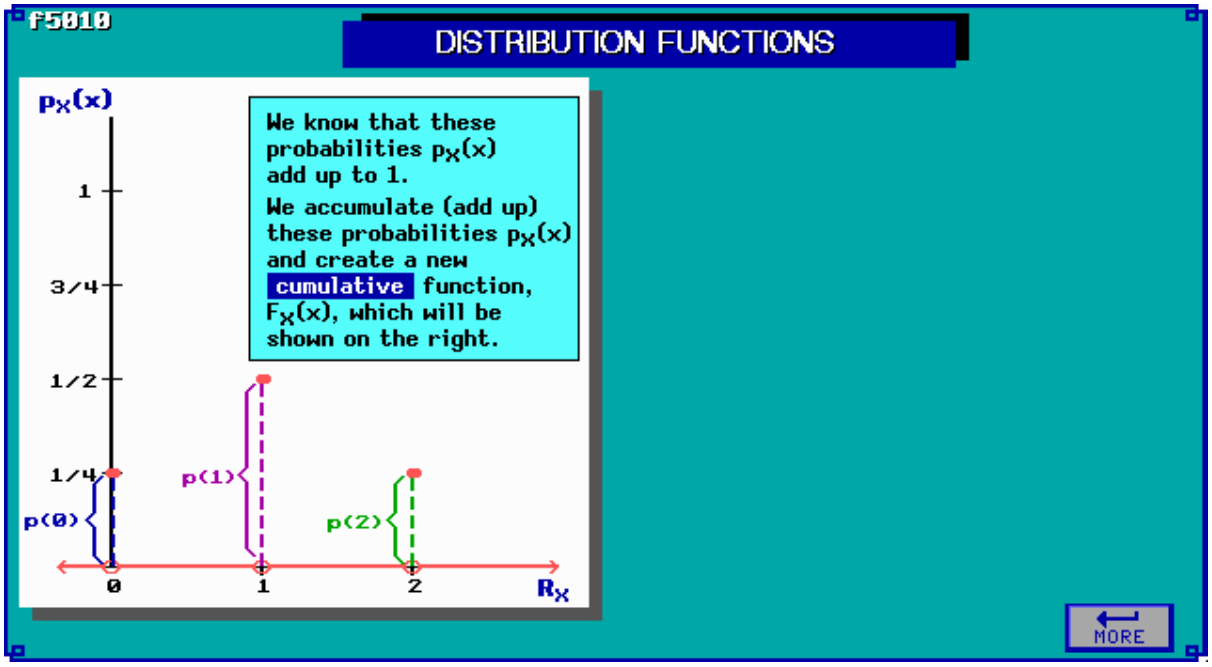



**Figure 3.12a Screen showing the beginning of the animation sequence, the p.d.f.**

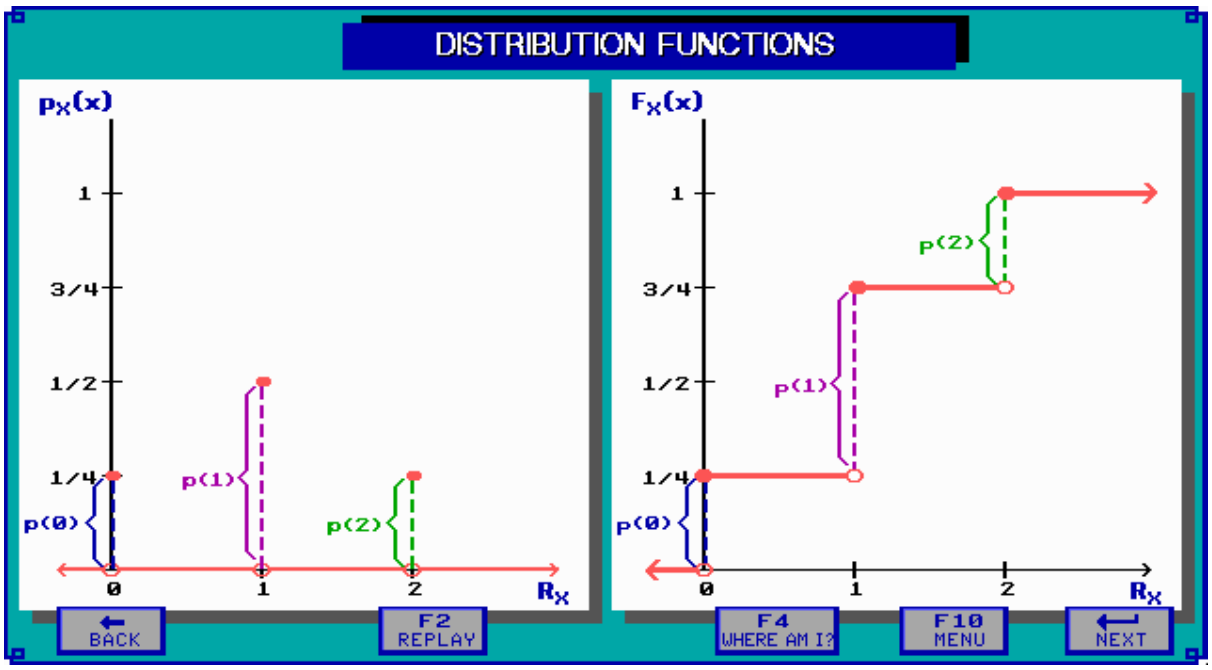



**Figure 3.12b Screen showing the c.d.f. generated dynamically from the p.d.f.**

### 3.6.2 Design blueprint

In order to save time and endless reinvention and modification further into the development phase (Gery, 1988), it is advisable to document design guidelines or standards. The design blueprint for this project included the following specifications.

#### No sound or video

The CATs produced for the Department of Statistics tend to be linear, without sound or video. The latter constraint was imposed by the probable low standard of hardware on student home computers. De Villiers et al. (1992) found that the use of audio and video was neither necessary nor desirable for distance students in their field. Statistics is a subject not dependent on sound (as a language or music would be), and graphical representation and animation are more applicable than video.

#### User interface

The user interface of the tutorials is relaxed and conversational, with the intention of encouraging a feeling of personal involvement for the student.

#### Language

The tutorials are programmed in English only, with special care being taken to use clear and simple language and to provide pop-up help windows for words or terms considered difficult for non-mother tongue speakers of English. A glossary of statistical terms is available via a function key, as shown Iin Figure 3.13

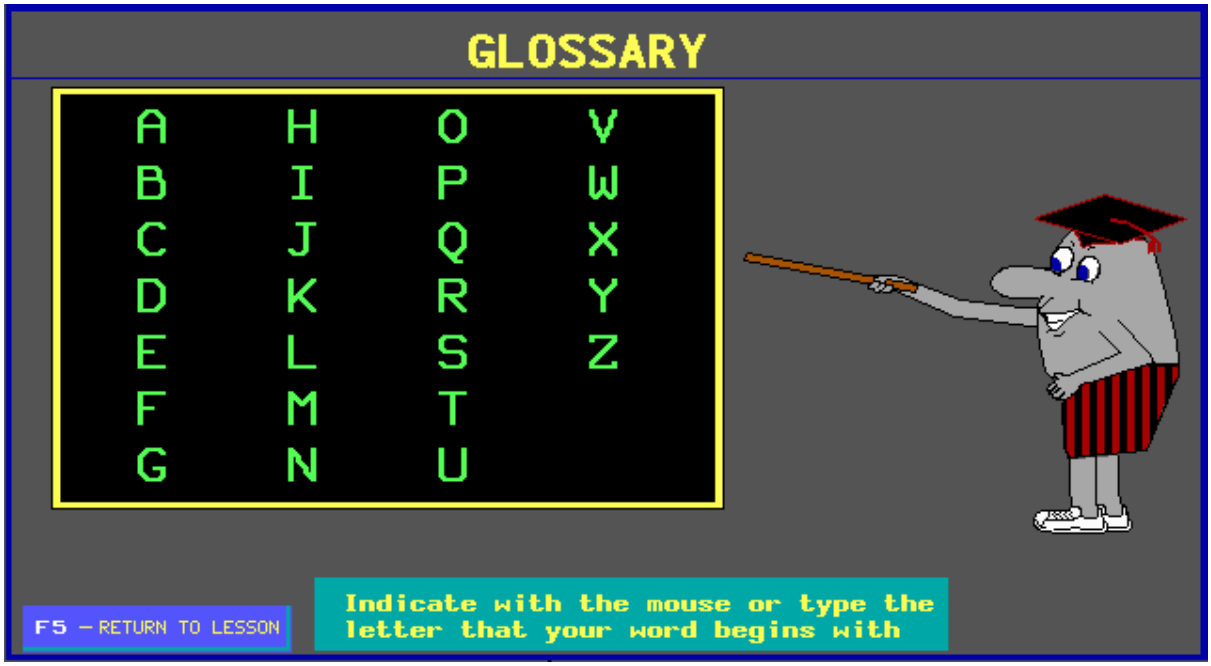



**Figure 3.13 Glossary lesson linked to all the CATs**

### Menu structure

The CATs are designed around a main menu, with various levels of sub-menus available as dictated by the content. A navigational feature available via a function key is the “Where am I?” option. To prevent the learner feeling lost in the various menu levels, this feature shows a snapshot of the menu, with the current section highlighted, as shown in the example Figure 3.14. On pressing Enter, the student is returned to the screen from where he or she accessed this feature.

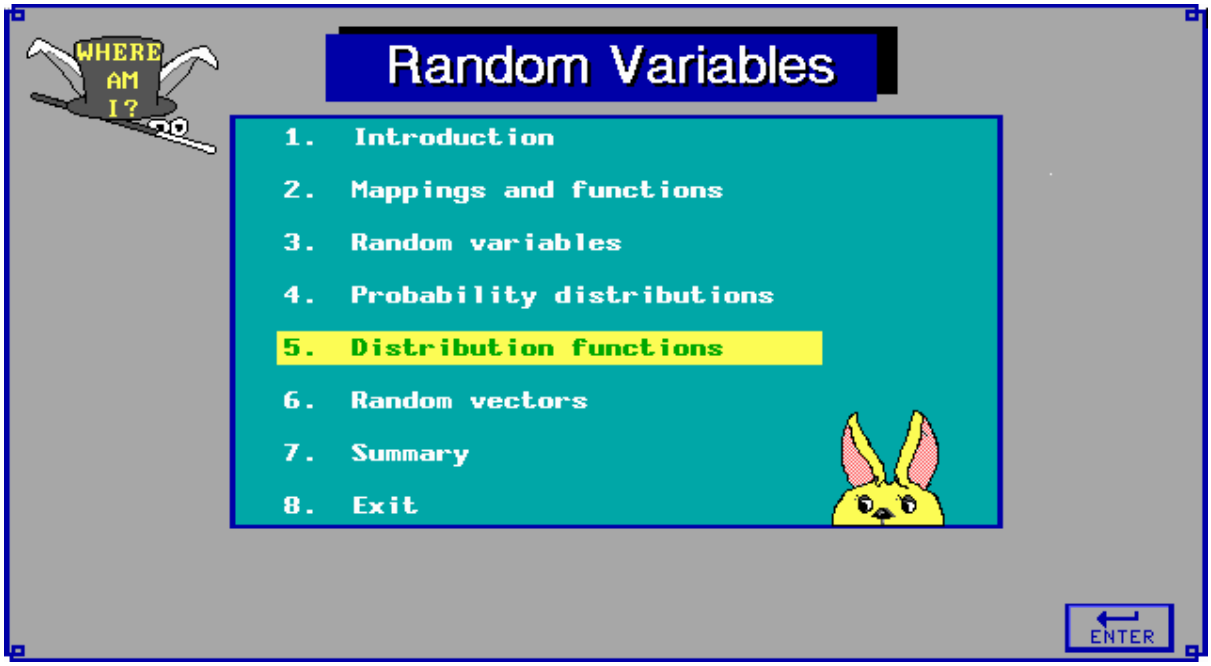



**Figure 3.14 The "Where am I?" feature**

### Navigation

For ease of student navigation, it was decided to make the **Back** (return to previous screen) and **Next** (continue to next screen) keys available on almost every screen. The only time that the Back key is not shown as an option is on the first screen of a new section, when Back simply returns the user to the menu screen from which a selection was made. On pressing Next at the end of a section, the user is likewise returned to the menu. The option to return to the Menu is always available. The option to escape or quit the programme is available from the Main Menu.

All the navigation options are shown as icons on the lower section of the screen. These icons are clickable, or alternatively activated via named function keys. In order to accommodate student needs and preferences, it was decided that the CATs should allow for both mouse and keyboard use.

### Fonts and colours

Three sizes of font are used consistently: standard font for the majority of the text, a larger font for headings and a smaller font for superscripts and subscripts necessary in mathematical formulae. The colour choice is consistent, as is the screen layout, with predetermined positions for headings, pop-up windows, icons and feedback boxes.

### Tutorial mode

In typical tutorial mode, after the presentation of a section of theory, the learner is given one or more questions to answer. The question screens are identified by a change of background colour and a large question mark in the top left hand corner.

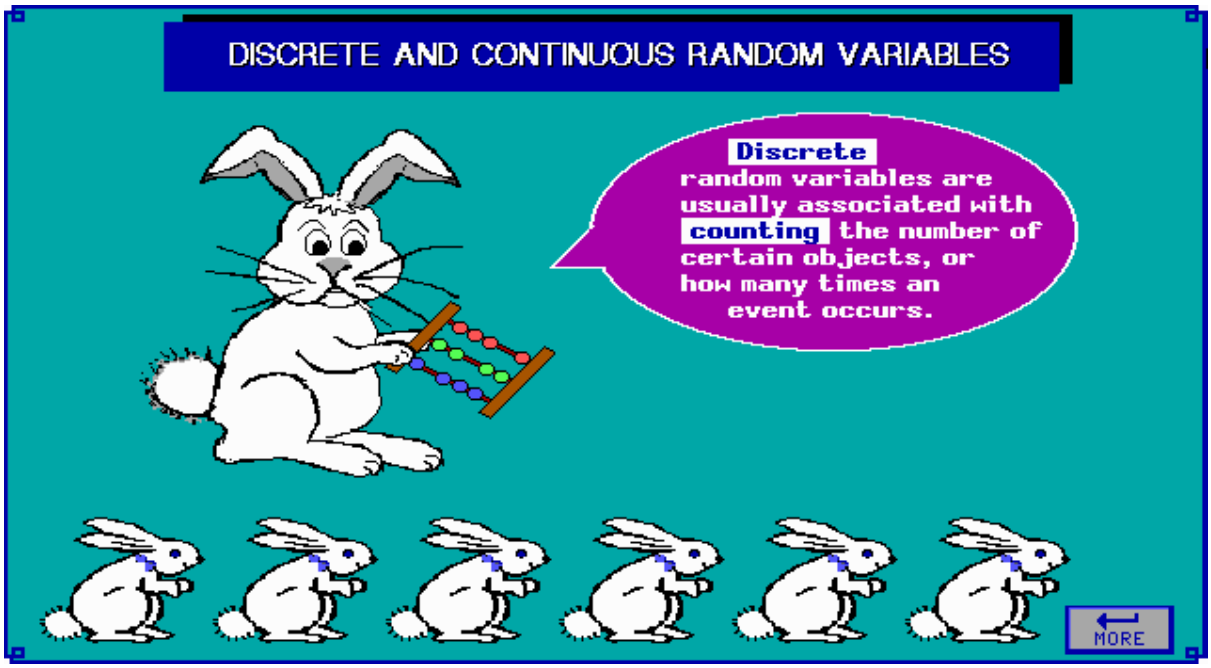



**Figure 3.15 Example of a presentation screen**

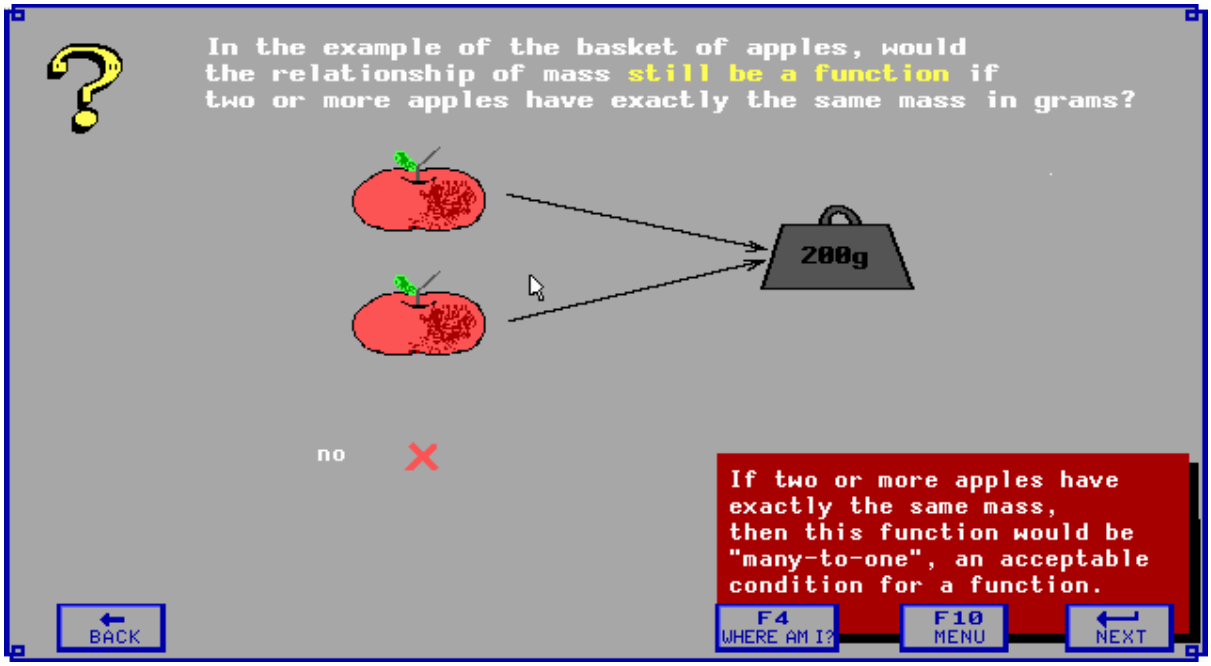



**Figure 3.16 Example of a question screen**

## 3.7 Development

### 3.7.1 Flowcharting

The structure of the study guide was used as the basic framework for the content of the CATs. The menu structure therefore reflects that in the study guide. Where necessary, additional sections were added in order to reinforce prior knowledge (e.g. the topic of “Mappings and Functions” was included, since this prior knowledge is necessary in order to understand the definition of a random variable as a function).

The flowchart of “Random Variables” is included in Appendix D.

### 3.7.2 Storyboarding

Detailed storyboards were drawn by hand for every screen of each tutorial. Two types of customised storyboard forms were used: one for presentation screens, with space for comments about layout, graphics, animations etc., and one for question screens, with space for correct, incorrect and unexpected answers and feedback. These storyboards were kept in a separate folder per tutorial, together with the timesheets of all team members involved, so that an estimate of the time taken for the development could be made.

Each CAT revolves around a particular theme character, to engage in dialogue (one-sided) with the student and to provide light relief where necessary. The theme character in the "Random Variables" tutorial is a white rabbit, which appears in various guises, using the theme of magic: a magic wand, a magician's hat, etc. Rough graphics of the theme character were indicated on the storyboards. The CENSE graphic artist then developed these in a graphics package and gave them to the author in *.pcx format.

### 3.7.3 Authoring

The author "authored" (programmed) the CATs in TenCore. This involved generating the code for each screen, producing diagrams and other graphics with the TenCore graphics editor where necessary and importing and modifying the computer graphics of the theme character.

The author tested each tutorial thoroughly from the technical point of view, trying to anticipate possible student responses and ensuring that there were no programming hitches.

On completion of the computer-based material, master diskettes of the CATs were produced. Each tutorial is available on either 360K floppy diskettes or 1.4 Mb stiffy diskettes (according to the needs of the students) and is accompanied by an installation booklet (reproduced in Appendix C). The installation booklets were designed by the author and produced by Unisa Press.

### 3.7.4 Description of the product and supporting material

The total package will consist of nine CATs, although this research report focuses on one, the sixth in the series, namely “Random Variables”. The tutorials are optional extra study resources, and students may purchase any or all of them, with the proviso that lesson 2 (Probability I) is a prerequisite for lesson 3 (Probability II), and lesson 6 (“Random Variables”) is a prerequisite for lesson 7 (“Descriptive Measures”).

The design and development cost for six CATs was approximately R70 000 for 24 months of part-time work. This does not include the services of the graphic artist nor the time taken by the full time Unisa staff members, both subject advisors and CAI experts.

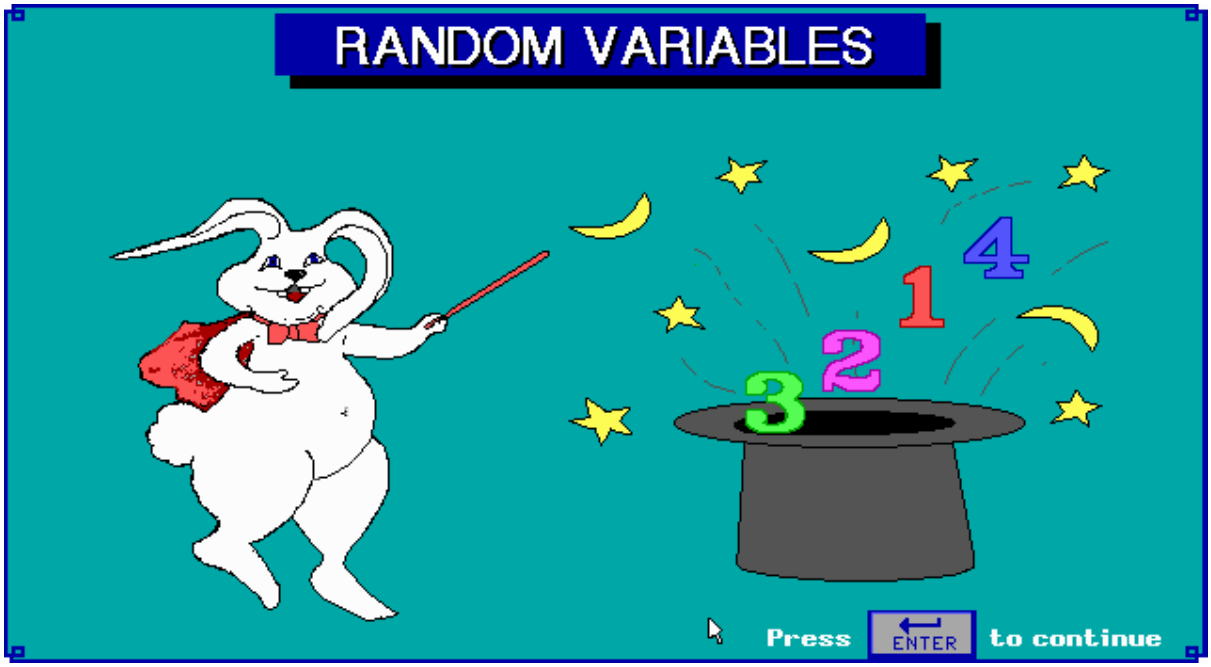



**Figure 3.17 Title screen of “Random Variables”**


**Figure 3.18 Credits screen of all the CATs**

## 3.8 Implementation

On completion of the first six CATs in March 1996, they were implemented with the student population in two ways:

1. The CATs were sent to the micro-computer laboratories at Unisa in Pretoria, as well as at the regional offices in Cape Town and Durban, with instructions to the laboratory supervisors as to how to install and run them. They are available for student use at no additional cost.

2. Students registered for STA101-H in 1996 were advised by tutorial letter of the availability of the CATs at the Unisa computer laboratory, as well as of the fact that the CATs could be purchased from Unisa Press at the cost of R25 per tutorial. Each tutorial is available on either 360K floppy diskettes or 1.4 Mb stiffy diskettes and is accompanied by an installation booklet.
   Telephonic support is offered to students by the subject advisors and the developer.

## 3.9 Summary

In 1994, the Department of Statistics at Unisa embarked on developing customised Computer-assisted Tutorials (CATs) as a supplementary, optional learning resource for the first year course STA101-H.

Being a course offered at a distance, special care was taken to design the CATs in such a way that the unique features of the computer, such as graphical display, animation and immediate feedback, would provide cognitive support and interaction for students normally studying in isolation.

This research report is the formal report on the analysis, design, development, implementation and formative evaluation of one of the CATs, “Random Variables”. All nine CATs, which will make up the final package, follow the same overall instructional strategy, design blueprint and development process.

# CHAPTER 4

# *RESEARCH METHODOLOGY*

## 4.1 Research problem

### 4.1.1 Aim of the research

The aim of this research is to design and develop a computer-assisted tutorial "Random Variables" and then to investigate and evaluate the impact of this program on a sample of students from the target population.

### 4.1.2 Objectives of the research

In order to achieve the above aim, the researcher's objectives were to:

- analyse the target population, the subject matter and appropriate hardware and software;
- design the tutorial "Random Variables" according to an instructional strategy incorporating cognitive learning theories;
- develop and test the tutorial "Random Variables" using the TenCore authoring package;
- modify the prototype after peer review by subject matter and computer-assisted instruction experts;

- implement the six tutorials, which have been developed to date, for students to work through on their own computers or in the Unisa regional micro-computer laboratories;

- evaluate the tutorial “Random Variables” by obtaining peer reviews and student feedback about various aspects of the program;

- assess what changes and modifications are required to improve the tutorial “Random Variables”.

## 4.2 Research questions

In order to evaluate the impact of the tutorial “Random Variables”, the following main questions arise:

1. What corrections and modifications to the program are required?
2. What are the cultural and language implications for the heterogeneous student population?
3. Does the teaching approach embodied in the program contribute to perceived learning gains?
4. Is it clear how to use the function keys and icons to navigate through the program?
5. What are the opinions, feelings and emotions of the learners on completion of the program?

Each of the main questions was investigated by considering the following sub questions:

| | QUESTIONS AND SUB-QUESTIONS |
|---|---|
| 1. | What corrections and modifications to the program are required?<br>1.1 Changes to the screen displays?<br>1.2 Changes to text layout?<br>1.3 Changes to colour usage?<br>1.4 Typographical errors?<br>1.5 Content errors?<br>1.6 Technical hitches? |
| 2. | What are the cultural and language implications for the heterogeneous student population?<br>2.1 Is anything in the programs offensive to certain cultures?<br>2.2 Is the level of English usage acceptable?<br>2.3 Is the use of vocabulary acceptable?<br>2.4 Is there any language which is vague or ambiguous? |
| 3. | Does the teaching approach embodied in the program contribute to perceived learning gains?<br>3.1 Is intuitive understanding of basic concepts facilitated?<br>3.2 Is the assumed prior knowledge acceptable?<br>3.3 Is the program suitable for adult learners?<br>3.4 Are terms and concepts clearly defined?<br>3.5 Does the student feel that learning has taken place?<br>3.6 Are the questions of an acceptable difficulty level?<br>3.7 Is it clear how answers should be entered?<br>3.8 Do the question episodes and feedback reinforce learning? |
| 4. | Is it clear how to use the function keys and icons to navigate through the program?<br>4.1 Is it clear how to move forwards and backwards through the program?<br>4.2 Is it clear how to make choices from the menus?<br>4.3 Is it clear how to use the function keys for special actions? |
| 5. | What are the opinions, feelings and emotions of the learners on completion of the program?<br>5.1 What are the opinions, feelings, emotions of the learners?<br>5.2 Are the graphics helpful and the comic characters acceptable?<br>5.3 How do the students rate the program? |

**Table 4.1 Research questions and sub questions**

## 4.3 Data collection

### 4.3.1 Description of methods and instruments

The instructional design model (Figure 4.1) on which this study is based, ensures that formative evaluation (and hence data collection) takes place at each of the stages of design, development and implementation.

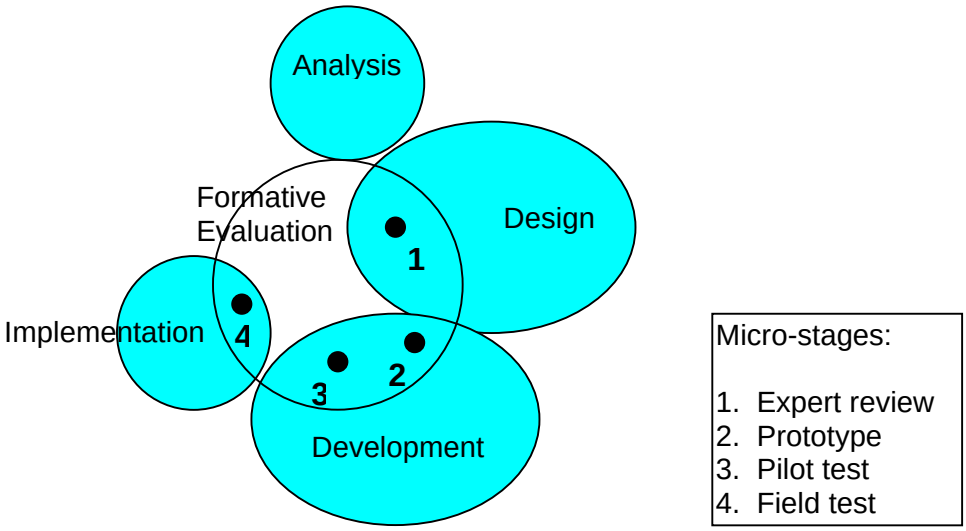



**Figure 4.1 Instructional design model for this study (Adapted from Hodgkinson (1996) and Beyer (1995))**

This chapter discusses the formative evaluation that took place at each micro-stage in the instructional design process.

Denzin (cited in Mouton & Marais, 1993) coined the term 'triangulation' to refer to the use of multiple data sources, multiple methods and multiple perspectives. According to Mouton and Marais (1993), triangulation is likely to increase reliability, since the complementary nature of multiple methods can counteract their respective shortcomings.

In order to increase the reliability of this study through triangulation, several different data collection methods and instruments were used. These are summarised according to the instructional design model, in Table 4.2.

| STAGE | MICRO-STAGE | METHOD | INSTRUMENT(S) |
|---|---|---|---|
| Design | 1. Expert review | Peer review | Evaluation notes |
| Development | 2. Prototype | Peer review<br>Focus groups | Evaluation notes |
| Development | 3. Pilot test | Survey<br><br>Discussion | Questionnaire<br>Error log<br>Anecdotal records |
| Implementation | 4. Field test | Survey<br><br>Observation<br>Telephone interviews | Questionnaire<br>Error log<br>Field notes<br>Interview schedule |

**Table 4.2 Methods and instruments**

### 4.3.2 Data analysis methods

It must be remembered that this study is intended to evaluate the product and not to measure the amount of learning that took place. As such, it is largely qualitative and descriptive in nature, with little statistical analysis, beyond frequency counts and the graphical representation of data.

The binomial test was used as a guideline for deciding when the frequency of a particular response to the questionnaire was statistically significant. According to binomial tables for a sample size of n=25, a frequency of 18 (i.e. 72%) is statistically significant (Hollander & Wolfe, 1973). For n=25, this statistic is the same for a two-sided and a one-sided test.

### 4.3.3 Data collection matrix

The data collection matrix, which shows which methods were used to collect data with respect to each main research question, as well as the team members involved at each stage, is given in Table 4.3.

| Method / Question | Peer review Focus groups | Survey | Observation | Telephone Interviews |
|---|---|---|---|---|
| Corrections/ modifications? | SME, CAIE, R | L SME | R | |
| Cultural / language implications? | SME, CAIE, R | L | | |
| Teaching approach? | SME, CAIE, R | L SME | | L |
| Clear navigation? | SME, CAIE, R | L SME | R | |
| Opinions, feelings and emotions? | | L SME | R | L |
| **Data analysis method** | edits to storyboards and prototype | descriptive statistics; binomial test | narrative | discussion |

L = Learners
R = Researcher
SME = Subject Matter Experts
CAIE = Computer-Assisted Instruction Experts

**Table 4.3 Data collection matrix**

## 4.4 Design stage: Expert review of the design

The CATs were designed in detail on paper (storyboarded). It was necessary to produce a complete set of detailed storyboards, so that the design could be evaluated at different times by various team members.

The paper-based design was evaluated by two subject advisors in the Department of Statistics and by three CAI advisors in CENSE. Comments and suggestions were noted (evaluation notes) and then the storyboards were returned to the author for modification before authoring began.

## 4.5 Development stage: Evaluation of prototype

After each tutorial had been programmed and sample diskettes had been produced, the evaluation cycle continued, with the same group of reviewers thoroughly evaluating the computer-based product. In so doing, they paid particular attention to technical details such as navigation, icons etc. and to didactic details, such as when a replay option or modifications to presentation, questions and feedback were required.

Their comments and suggestions were recorded on paper and discussed in focus groups, and then agreed changes and edits were implemented by the author.

Version 2 of the prototype was then produced.

## 4.6 Development stage: Pilot test with staff members

A pilot test was conducted with five staff members during January 1996. The staff members worked through the tutorial “Random Variables”, as if they were students,

and then completed the draft questionnaire and the error log. The error log was two separate sheets of paper given to each participant on which they were asked to record details of any typographical errors, content errors, technical hitches or ambiguous language.

The staff members were encouraged to make suggestions as to how the questionnaire could be improved to eliminate ambiguities. These suggestions are discussed in Chapter 5, section 5.3.

The final questionnaire appears in Appendix F and the error log in Appendix G.

## 4.7 Implementation stage: Field test with students

### 4.7.1 Preparation of the questionnaire

The design and compilation of a questionnaire is not a trivial task. Special care must be taken to ensure that the questions are concise and unambiguous and that they will test what the researcher wishes to test.

Duverger (1964, p.144) states: *"The preparation of questionnaires is a complex and delicate operation. The nature, form and order of the questions is of great importance to the results of the inquiry."* He goes on to add:

> *"A questionnaire is not a series of questions in any order. It is, on the contrary, a group of questions the order of which is very carefully studied. The order, the number of questions about the same subject, their grouping in 'batteries' present difficult and important problems"* (Duverger, 1964, p.148).

In developing the questionnaire for this study, other questionnaires for the evaluation of computer-assisted lessons were consulted (Möller, 1993; de Villiers, 1993; Cronjé, 1993). Customised questions for this project were drafted and reviewed with experts in the field of questionnaire design, both at Unisa and at the University of Pretoria.

After five revisions, the questionnaire was translated into Afrikaans and both the English and Afrikaans versions were typed. Even then, it was discovered later, that in translation, the emphasis of one particular question had been unintentionally switched from positive to negative.

**Reliability**

Mouton and Marais (1993) describe various orientations of respondents, which may affect the reliability of a test. For example, the well-known Hawthorne effect is an example of a social desirability tendency, with the respondent attempting to give those responses which are considered desirable and admirable.

Another participant effect described by Mouton and Marais (1993) is what they call the *"acquiescent response set"* (p.889), which describes the tendency to answer "yes" or "no" to virtually all the items in a questionnaire. They refer to Sletto (cited in Mouton & Marais, 1993), who, as early as 1937, found that respondents were more likely to agree with a statement than to disagree with the inverse of that statement.

In order to counteract this tendency, several statements which anticipated disagreement were included in the questionnaire.

The table on the following page shows how each research question is addressed by one or more particular questions on the questionnaire and/or the error log.

| | QUESTIONS and SUB-QUESTIONS | QUESTIONNAIRE numbers | ERROR LOG |
|---|---|---|---|
| 1. | What corrections and modifications to the program are required? | | |
| | 1.1 Changes to the screen displays? | 17 | |
| | 1.2 Changes to text layout? | 18 | |
| | 1.3 Changes to colour usage? | 19 | |
| | 1.4 Typographical errors? | | yes |
| | 1.5 Content errors? | | yes |
| | 1.6 Technical hitches? | | yes |
| 2. | What are the cultural and language implications for the heterogeneous student population? | | |
| | 2.1 Is anything in the programs offensive to certain cultures? | 12, 13, 19 | |
| | 2.2 Is the level of English usage acceptable? | 32 | |
| | 2.3 Is the use of vocabulary acceptable? | 33 | |
| | 2.4 Is there any language which is vague or ambiguous? | 34 | yes |
| 3. | Teaching approach? | | |
| | 3.1 Is intuitive understanding of basic concepts facilitated? | 15, 16 | |
| | | 11 | yes |
| | 3.2 Is the assumed prior knowledge acceptable? | 14 | |
| | 3.3 Is the program suitable for adult learners? | 35 | |
| | 3.4 Are terms and concepts clearly defined? | 41,42 | |
| | 3.5 Does the student feel that learning has taken place? | 38 | |
| | 3.6 Are the questions of an acceptable difficulty level? | 37 | |
| | 3.7 Is it clear how answers should be entered? | 36, 39, 40 | |
| | 3.8 Do the question episodes and feedback reinforce learning? | | |

| | | | |
|---|---|---|---|
| 4. | Clear how to navigation through the program?<br>4.1 Is it clear how to move forwards and backwards through the lesson?<br>4.2 Is it clear how to make choices from the menus?<br>4.3 Is it clear how to use the function keys for special actions? | <br>23, 24<br>25, 26, 27<br>28 | |
| 5. | Opinions, feelings and emotions of the learners?<br>5.1 Are the graphics helpful and the comic characters acceptable?<br>5.2 What are the opinions, feelings, emotions of the learners?<br>5.3 How do the students rate the program? | <br>20, 21, 22<br>43 - 49, 51 and 54 - 56<br>50, 52, 53 | |

**Table 4.4 Matrix matching research questions with questionnaire and error log**

### 4.7.2 Sampling procedure

In preparing for a field test with students, it was necessary to consider what sampling procedure to use. The difficulty with a distance education institution is that travel restrictions make it almost impossible to select a random sample of students, since students registered for the course are geographically dispersed.

It was decided to take a convenience sample from students living in Gauteng, who would be prepared to travel to the micro-computer laboratory on the Unisa campus in Pretoria. According to this method of sampling, the nearest or most convenient population elements are drawn into the sample (Cohen & Manion, 1994). As an incentive to attend, students were offered a cash contribution towards their travelling expenses. Fruit juice was provided but students were requested to supply their own meals for the day.

The students who took part in the study were volunteers and therefore did not necessarily constitute a representative sample of the student population registered for STA101-H. Cohen and Manion (1994) discuss the merits of a convenience sample, notwithstanding the fact that one cannot generalise from the findings:

> *"Small-scale surveys often resort to the use of non-probability samples because, despite the disadvantages that arise form their non-representativeness, they are far less complicated to set up, are considerably less expensive, and can prove perfectly adequate where researchers do not intend to generalize their findings beyond the sample in question"* (Cohen & Manion, 1994, p. 88).


**Gonick & Smith (1993, p.97)**

In order to broaden the sample, the CATs were installed in the regional offices in Cape Town and Durban and students who attended the discussion classes there during May 1996, were encouraged to work through the CATs and to complete the questionnaire.

No funding was available for the researcher to travel to Durban and Cape Town to run field tests there. There was also the logistical difficulty of asking students in those regions to attend the full day discussion class as well as to make further travel

and/or leave arrangements to attend a field test of the CATs, which would take another full day.

Unfortunately the attendance at the regional discussion classes was minimal and no completed questionnaires were received from Durban or Cape Town.

A possibility for further research would be to investigate how to obtain a representative random sample of respondents and to conduct a field test on a larger scale, perhaps offering some type of course credit to participants as an incentive. Without some sort of incentive, it is doubtful whether many students would complete and return voluntary questionnaires. Alexander et al. (1992) found that only three out of 28 students registered for a module in computer science returned voluntary questionnaires.

### 4.7.3 Conducting the field test

Field testing is part of formative evaluation, in that the main purpose of the field test is to determine if changes need to be made, based on use of the product by students from the target population (Callison & Haycock, 1988). These authors describe field testing as follows:

> *"Field testing involves the actual use of the materials with students and teachers interacting within the normal educational setting for which the materials have been designed for future use"* (Callison & Haycock, 1988, p.26).

The tutorial letter requesting participants for the field test was sent to all 339 students registered for STA101-H during January 1996. The field test was scheduled for March 1996. A copy of the tutorial letter is included in Appendix E.

It was decided that the students would be asked to work through two of the CATs, namely "Probability I" and "Random Variables" and that 10 hours should be allowed

for the exercise, including breaks. Three alternative arrangements were offered: a full day on a Friday, or a Friday afternoon and Saturday morning, or two consecutive Saturday mornings. Since most of the students are employed full time and study part time, it was necessary to consider constraints imposed on them by their working conditions.

Thirty five students responded to the invitation to participate in the field test. Ultimately only 25 attended and completed the questionnaire.

The field test was conducted as follows:

1. The students were welcomed and thanked for attending; they were told about the project and the availability of the CATs for purchase and home use.
2. The procedure for the day was explained, namely that they would work through two of the CATs and fill in the questionnaire on completion.
3. The questionnaire was not handed out at the start of the day, because it was necessary for the students to concentrate on the CATs and to form their opinions without being influenced by what appeared on the questionnaire.
4. The anonymity of the author as the designer and developer of the CATs was maintained, in order to avoid the Hawthorne effect (Mouton & Marais, 1993) of respondents providing replies that they might think are desirable.
5. The students were asked to look out for features in the CATs, such as screen layout, use of language, teaching approach, use of graphics, questions-answers-feedback etc.
6. Terms that might have been unfamiliar were explained, such as **graphics**, **feedback**, **icons,** etc.

One of the objectives of the study was to investigate what changes and modifications might be necessary in order to improve the tutorials. The students needed to be able to record more than what was asked for on the questionnaire. They were therefore supplied with an error log on which they were asked to record details of any

typographical errors, content errors, technical hitches or ambiguous language. The error log is reproduced in Appendix G.

The students worked through the two CATs at their own pace, each at their own computer. Supervisors were on hand to answer questions, both about the use of the computer and about the subject matter, when necessary. The researcher observed the students and made field notes about their progress, time taken, body language etc. Most students were able to complete the two CATs in a half-day session, although some did return for the second session.

On completion of the CATs the students filled in the questionnaire on their own. Follow-up telephone interviews were conducted during August 1996. The students were advised that the purpose of these interviews was for research on computer-assisted instruction and would not affect their student records in any way.

## 4.8 Summary

This chapter describes the ongoing formative evaluation of the tutorial “Random Variables” which took place during four micro-stages of the instructional design model:

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

Computer-assisted instruction experts and subject matter experts evaluated the paper-based storyboards and the prototype computer-based product in a cycle of review, editing and further review.

The main instrument of measurement for the pilot test and the small-scale field test was an extensive questionnaire that had been carefully designed, so as to be totally

customised for the particular computer-assisted tutorial being evaluated, namely "Random Variables". The questionnaire addressed all the research questions and sub-questions of this study.

The pilot test was conducted in January 1996 with five members of staff from the Department of Statistics at Unisa. In March 1996 the small-scale field test was conducted in the computer laboratory at Unisa, with 25 students registered for STA101-H. The students were volunteers and were offered a financial contribution towards their travelling expenses. Being a distance education institution, it is difficult to obtain a random representative sample, due to the geographical dispersion of the students.

Follow-up telephone interviews were conducted with the same group of student volunteers during August 1996. The interview was also used as an opportunity to survey the computing facilities available to students, which will inform future multi-media developments.

The findings of the formative evaluation are discussed in Chapter 5.

# 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.

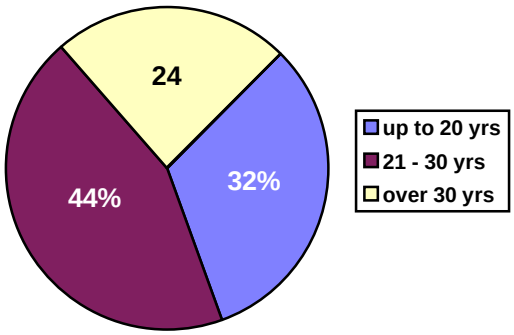



**Figure 5.1 Age of the respondents**

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

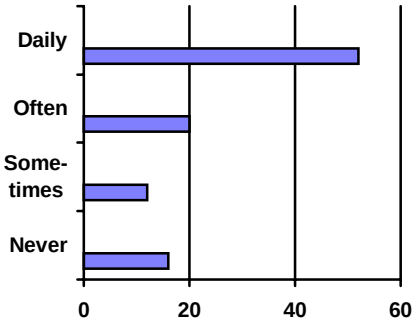



**Figure 5.2 Computer usage of respondents (%)**

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.

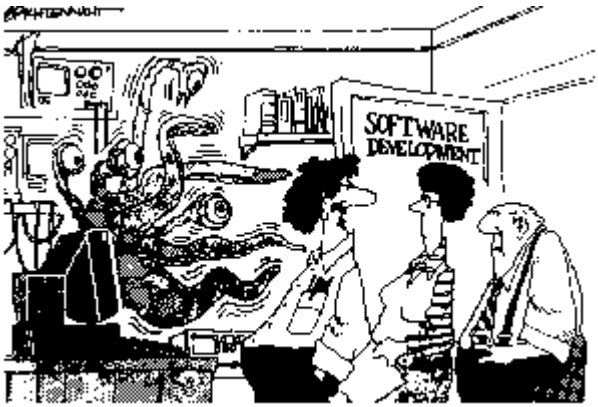
In practice, this should not present a problem, since it is not necessary to complete a tutorial in one sitting. All the tutorials record completion data, so that an individual student can continue later, without losing credit for sections completed. This assumes that the student is working on his or 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**

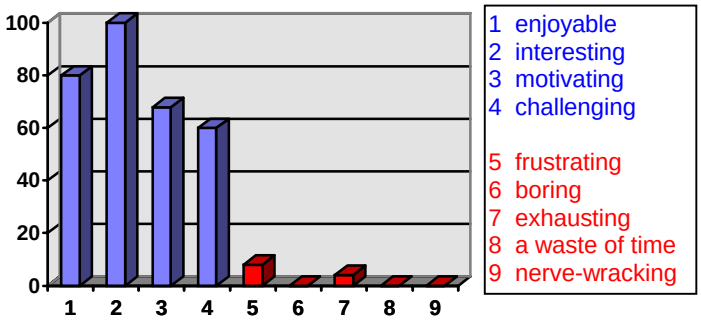



**Figure 5.3 Learners' opinions about the tutorials (%)**

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%.

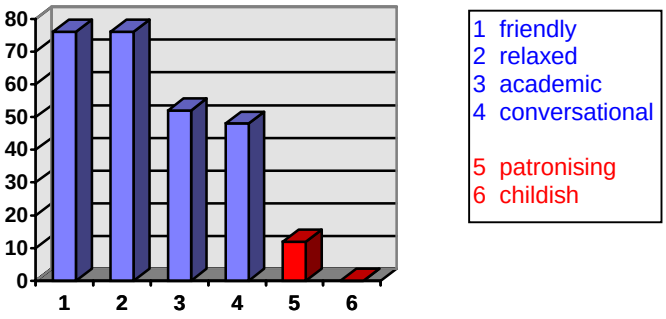



**Figure 5.4 Learners' opinion about the tone of the tutorials (%)**

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.

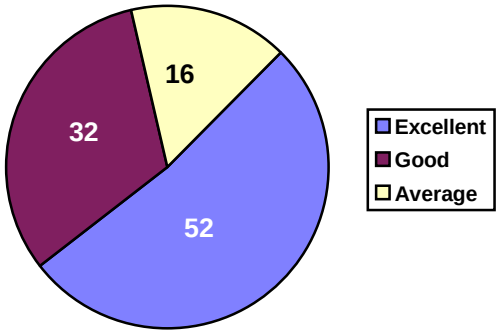



**Figure 5.5 Student rating of the tutorials (n=25)**

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.

# CHAPTER 6

# *CONCLUSIONS AND RECOMMENDATIONS*

## 6.1 Conclusions

The overall response of the students using the computer-assisted tutorial "Random Variables" was extremely positive and encouraging. The conclusions to each of the five main research questions are discussed below.

| Question 1: |
| --- |
| What corrections and modifications to the program are required? |

Staff and students experienced no difficulties with regard to screen displays, text layout or use of colour. They enjoyed the colour, the graphics and the animation and found the program user-friendly. No content errors, typographical errors or technical hitches were identified, which illustrates the effectiveness of the ongoing formative evaluation process.

| Question 2: |
| --- |
| What are the cultural and language implications for the heterogeneous student population? |

Concerns which had existed in connection with the effect of certain colour conventions and theme characters on members of various different ethnic groups proved to be groundless.

Similarly, the level of English language usage was acceptable for non-mother tongue speakers of English who had studied the English study guide. However, Afrikaans speaking students had some problems with the English terminology in the computer-assisted tutorials (CATs), having studied the material in the Afrikaans study guide.

No cases of vague or ambiguous language were identified.

| Question 3<br>Does the teaching approach embodied in the program contribute to perceived learning gains? |
|---|

The respondents felt that the learning material was presented in a manner which enhanced their understanding of the basic concepts, which tend to be rather abstract. They felt that the CATs make the subject of Statistics more interesting and more understandable. They definitely felt that working through the tutorials would help them with their revision before the examination.

Several students expressed the desire for more questions and exercises, of a difficulty level in keeping with that expected in the assignments and examination.

| Question 4<br>Is it clear how to use the function keys and icons to navigate through the program? |
|---|

No problems were experienced with navigation through the program. Orientation techniques such as headings, completion asterisks on the menus and the “Where am I?” feature prevented the students from becoming disorientated.

| Question 5<br>What are the opinions, feelings and emotions of the learners on completion of the program? |
|---|

The students were motivated by using the CATs and found them to be enjoyable, interesting and challenging. They found the interface to be friendly, relaxed and conversational. More than half of the students rated the tutorials as excellent and all would recommend them to other students.

## 6.2 Limitations of this study

This study is limited by certain issues which preclude making any generalisations from the findings. These limitations are discussed in turn below.

### 6.2.1 Sampling procedure

Since Unisa is a distance education institution, with many students studying part time and by correspondence, the sampling procedure for the field test needed to take into account the following issues:

- the geographic dispersion of students meant that students had to be prepared to travel to Pretoria;
- the employment conditions of students meant that they had to be able to take leave from their work places in order to attend the field test in Pretoria.

These issues indicated that a convenience sample (Cohen & Manion, 1995) was necessary. All students registered for the course (339) were notified of the research project and were invited to participate in the field test. The limitation of this method of sampling is that it does not necessarily generate a sample representative of the whole population.

### 6.2.2 Sample size

Due to the fact that we had to rely on a convenience sample of volunteers, we were not able to control the sample size.

Lee and Mamone (1995) recommend trying for a sample size of 10% of the population. With 339 students registered for the course, the desired size of the sample was 34. We received 35 replies to the invitation to take part in the field test, but of these, only 25 students actually participated and completed the questionnaire.

Since this is an exploratory and largely qualitative study, the small sample size did not impact on any statistical tests. The limitation of the small sample size, simply meant that the findings are not generalisable to the whole student population.

This was especially evident when the telephone interviews revealed that some students have top-of-the-range computing equipment, while others have no access to computers, except for the Unisa computer laboratories.

### 6.2.3 Hawthorne effect

Mouton and Marais describe the Hawthorne effect by saying*: "The mere fact that human beings are studied, leads to atypical behaviour"* (Mouton & Marais, 1993, p.86). The subjects of a research project may feel flattered to be part of the investigation and may respond in ways that they feel are desirable, admirable and rational.

In this study, in particular, the questionnaire items about learning gains asked the students' opinion as to whether they had learnt something about Statistics. Their opinion may not necessarily correlate with actual learning gains, if these had been measured.

## 6.3 Recommendations

### 6.3.1 Learning gains

In order to counteract the Hawthorne effect described in section 6.2.3, it would be desirable to implement a pre-test and a post-test to measure actual learning, irrespective of student opinion of perceived learning gains.

Gery (1988) makes the point that enjoyment of the learning experience should not be assumed to imply that learning is taking place. In this study, the students clearly found the learning experience enjoyable and interesting (see Chapter 5). This study therefore generates the hypothesis that learning gains are evident. Measuring the extent of such learning gains would be the subject of further research and would make a start with the summative evaluation of the CATs.

In such future studies with distance students, it will be necessary to investigate how to obtain a larger and therefore more representative sample. This study has shown that relying on the voluntary return of questionnaires and voluntary participation in a field test does not yield a sample large enough to enable generalisation of the findings.

### 6.3.2 Effectiveness of the electronic medium

Allied to the need to measure learning gains, is the need to measure the effectiveness of the electronic medium as opposed to the traditional paper-based media generally used in distance education institutions.

A follow-up study, with an experimental group (receiving the computer-assisted instruction) and a control group (receiving traditional instruction), could be considered. However, such a scenario poses two philosophical dilemmas:

- student participants should not be unduly disadvantaged by being the subject of one treatment or the other;

- the computer-assisted tutorials are intended to supplement traditional instruction and not to replace it.

Furthermore, in the light of meta-analyses done in this field (Kulik & Kulik, 1986; Kulik et al, 1980) and the "method versus media" debate (see Chapter 2), claiming that a particular medium is more effective than another is fraught with the dangers of bias, misdirected inference and questionable validity.

It would appear, therefore, that it would be more beneficial to measure learning gains as suggested in section 6.3.1, than to measure the effectiveness of the electronic medium per se.

### 6.3.3 Computer-based testing

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

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

These three areas are discussed in turn below.

**Instructions**

In general when a question awaits a student answer, an arrow indicates that input is required. In rare instances, rhetorical questions are posed on presentation screens. The instructions on how and when to answer questions will be reviewed to make sure that they are clear at all times. In "Random Variables", the student is often required to complete figures in a table. In such instances, the provision of a cursor awaiting input may be helpful.

**Feedback**

During the design of the CATs, an attempt was made to provide specific and helpful feedback, especially after wrong answers. However, one of the peer reviewers felt

that the feedback was not particularly ambitious and students also felt that the feedback could have been more directed. The provision of more individualised and specific feedback will be considered, together with allowing the student to enter progressive results during long calculations, so that his progress can be guided with response-related feedback.

**Number of questions**

The design and development of computer-based tests needs to be considered to provide more practice, with immediate feedback and various difficulty levels. Since extended practice and testing is not the domain of computer-assisted tutorials (Alessi & Trollip, 1991), "Random Variables" does not attempt to provide this. However, this need was expressed by the students, and therefore needs to be investigated. Scoring and record keeping would be helpful, both for the purposes of self-assessment, and for instances when a lecturer may require details of student progress.

### 6.3.4 Language issues

Although it would be desirable to offer the CATs in the mother-tongue of the learner, language issues in South Africa at present are the subject of debate and change. The translation of the CATs into other languages needs to be considered in the light of the following factors:

- the translation of the study guides into African languages;
- the fact that text books and the examinations are in English or Afrikaans;
- the viability of translating a technical subject like Statistics into African languages, which may not have the necessary technical vocabulary;
- the cost of translation, development and testing.

## 6.4 Summary

This study has considered the analysis, design, development, implementation and formative evaluation of “Random Variables”, one of a series of nine CAI tutorials developed specifically for a first year Statistics course at Unisa.

In the distance education scenario, computer-assisted tutorials (CATs) provide an additional, supplementary learning resource. The intention is to attempt to decrease the isolation of the student studying by correspondence, and to increase their amount of interactivity with the subject material.

In the teaching of Statistics as a subject, there is a need to present underlying abstract concepts in a constructivist way (see Chapter 2), in addition to the usual formal mathematical approach. The aim is to encourage a deeper and more meaningful understanding of what these concepts and terms really mean.

Computer-assisted tutorials provide the opportunity to merge these aims and intentions, with the computer medium making possible graphics, demonstrations and animations that are not possible with other instructional media.

“Random Variables” was implemented in a field test with 25 volunteers from the student population. The responses to the questionnaire and the follow-up telephone interviews were extremely positive. Respondents made constructive suggestions for the enhancement of the CATs, which is, after all, the main purpose of formative evaluation.

The overall findings of this study are encouraging. The CATs have been through several stages of formative evaluation and extensive feedback from peers, staff members and students has been obtained. This feedback will guide the summative evaluation process and the development of further tutorials in the series.

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# Appendix A

# Hardware Requirements

In order to run the tutorial “Random Variables”, you will need an IBM or other MS-DOS compatible computer with the following components:

- 640 Kb RAM memory;
- Hard disk drive with at least 3 Mb free space;
- EGA graphics card or better;
- VGA colour monitor;
- 1.44 Mb 3½ inch disk drive (stiffy drive);
- DOS 3 or higher;
- Mouse is optional, since the lesson accepts either mouse or keyboard input.

# Appendix B

# Quick Installation Guide

To install the program, insert the diskette in your A or B drive, whichever is applicable. Make sure you are in the root directory C: and in DOS. The lesson runs under DOS and not WINDOWS.

Depending on whether you are using the A drive or the B drive, do the following:
Type either

**COPY A:INSTALLA.BAT C:** or **COPY B:INSTALLB.BAT C:**

Then type either

**INSTALLA** or **INSTALLB**
and press Enter.

The installation takes a few minutes. When it is complete, change to directory C:\STA101 using the normal DOS commands and type RANDOM to start the lesson.

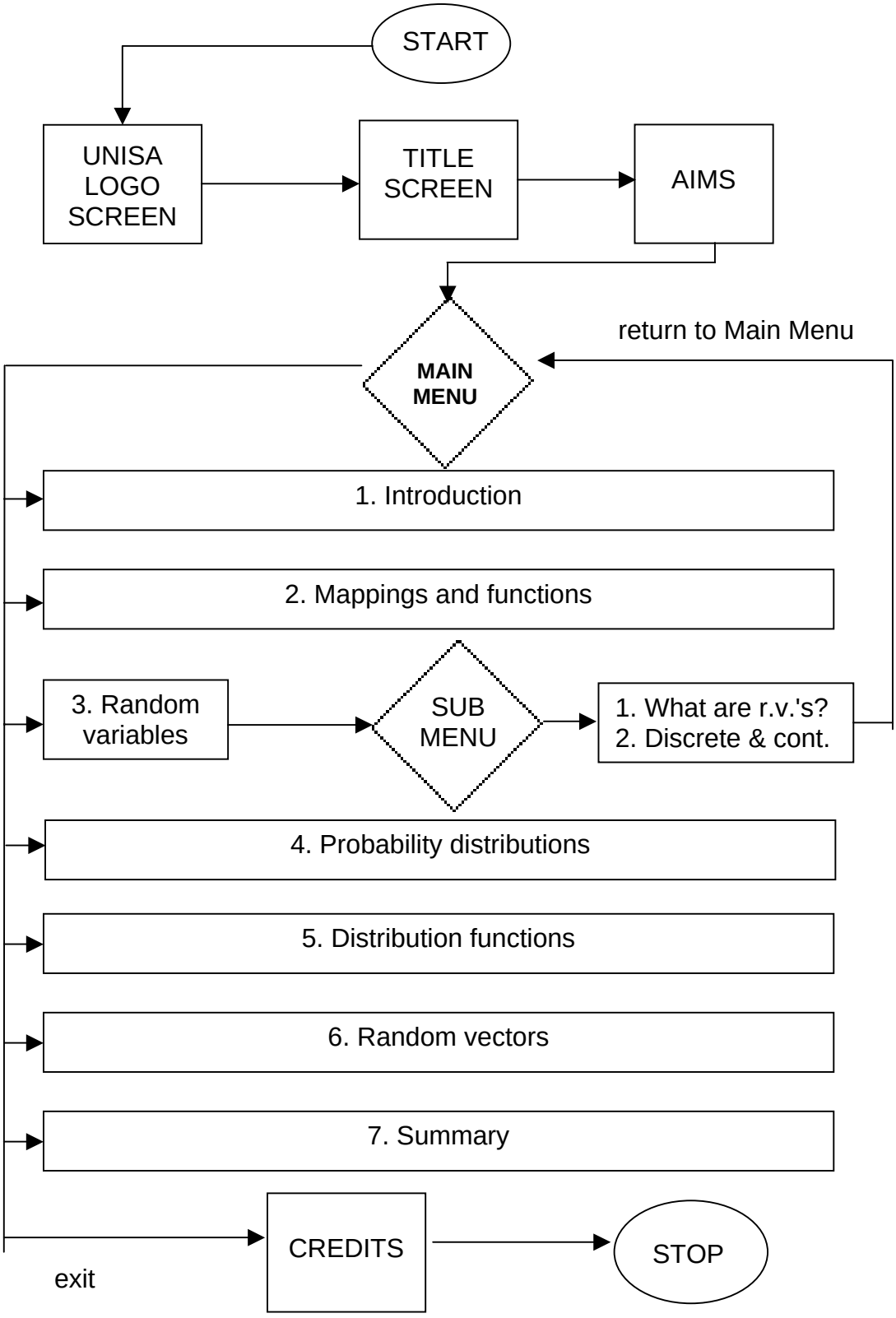
# Appendix C

# Installation Booklet Sent to Unisa Students

**This Appendix not published on the Web**

## Appendix D

## Flowchart for the tutorial “Random Variables”



# Appendix E

# Tutorial Letter Requesting Participants

Fakulteit Natuurweetenskappe


Faculty of Science

## DEPARTMENT OF STATISTICS

### PARTICIPATION IN COMPUTER-ASSISTED INSTRUCTION (CAI) PROJECT

### WE NEED YOUR HELP

Those of you who are familiar with microcomputers will realise that a computer can be a valuable teaching medium for a subject such as Statistics. The Department of Statistics is designing and developing computer-assisted lessons to supplement the Study Guide for STA101-H.

The lessons are interactive tutorials (not just question banks) which demonstrate and explain the material in the Study Guide from a point of view that is designed to encourage deeper intuitive understanding of the topics. Especially in the distance education setting, the special features of a computer make it possible to provide a richer learning experience than is possible in a written medium. In other subjects where computer-assisted lessons have been implemented, the students were of the opinion that they were a very helpful learning aid.

### HOW CAN YOU HELP US?

Before the Statistics CAI lessons can be made available to all STA101-H students, we need to test them with a group of students and to receive your comments and feedback so that we can improve the lessons where possible.

We need your help to evaluate the lessons as study material from the student's point of view. Without your input, it is impossible to carry out a scientific evaluation. The results of your evaluation will be used in research at Unisa and at the University of Pretoria.

We invite all students living in the Pretoria-Johannesburg are, or who are prepared to travel to Pretoria, to take part in the evaluation project.

**WHEN?**

During the second half of March 1996.

**WHERE?**

Unisa main campus - Cas van Vuuren Building.

**HOW LONG WILL IT TAKE?**

Probably a total of six to ten hours, which can be distributed over two days. Different options are available, which are described on the form to be completed on page 5.

**WHAT MUST YOU DO NOW:**

Please complete the enclosed form if you would like to participate in the project. The closing date for replies is the end of February - the same as for Assignment 01. You can staple the reply to the inside of the assignment cover for Assignment 01, or you can send it directly to:

Mrs J Fresen
Department of Statistics
Unisa
P.O. Box 392
Pretoria 0001

We will contact you in due course for final arrangements if you have been included in the sample to take part in the project. We hope to involve 60 to 80 students.

Thank you very much for your cooperation.

Mrs J. Fresen
Mrs J. Jordaan
Mr P. Debba

Department of Statistics
UNISA

January 1996

# EVALUATION QUESTIONNAIRE FOR LEARNERS

## COMPUTER-ASSISTED INSTRUCTION: STATISTICS

**Circle** the number(s) of your choice.

**Section 1: Personal information**

For office use

| | | |
|---|---|---|
| 1. *Respondent number* | *V1* | *1-4* |
| 2. *Card number* | *V2* *0* *1* | *5-6* |
| 3. *Repetition number* | *V3* | *7* |

4. Your gender:

| | |
|---|---|
| Male | 1 |
| Female | 2 |

V4 ☐ 8

5. Your age:
Please give your age in completed years:
_____ years

V5 ☐☐ 9-10

6. Which **one** of the following languages do you speak at home **most often**?
(Circle **only one** number.)

| | |
|---|---|
| English | 1 |
| Afrikaans | 2 |
| Zulu | 3 |
| Xhosa | 4 |
| Swazi | 5 |
| Ndebele | 6 |
| Southern Sotho | 7 |
| Western Sotho (Tswana) | 8 |
| Northern Sotho (Pedi) | 9 |
| Shangaan/Tsonga | 10 |
| Venda/Lemba | 11 |
| Other: (specify) | 12 |
| ..... | |

V6 ☐☐ 11-12

For office use

7. How frequently do you use a computer apart from computer games?
(Circle the **one** number which is most appropriate for you.)

| Never | Sometimes | Often | Daily |
|---|---|---|---|
| 1 | 2 | 3 | 4 |

V7 ☐ 13

8. How long did it take you to complete each of the two lessons?
(Circle a number for each lesson.)

| | < 2 hours | 2 to 3 hours | 3 to 4 hours | > 4 hours |
|---|---|---|---|---|
| 1. Probability I | 1 | 2 | 3 | 4 |
| 2. Random variables | 1 | 2 | 3 | 4 |

V8 ☐ 14
V9 ☐ 15

9. Consider the length of time required to complete each lesson

| | Too short | Satis-factory | Too long |
|---|---|---|---|
| 1. Probability I | 1 | 2 | 3 |
| 2. Random variables | 1 | 2 | 3 |

V10 ☐ 16
V11 ☐ 17

## Section 2: Evaluation of lessons

For office use

Please indicate your level of agreement with each of the following statements by circling a number:

| | Strongly agree | Agree | Dis-agree | Strongly disagree | | |
|---|---|---|---|---|---|---|
| 10. The content of the computer lessons follows a logical sequence | 1 | 2 | 3 | 4 | V12 | 18 |
| 11. The lessons assumed more mathematical background knowledge than I have | 1 | 2 | 3 | 4 | V13 | 19 |
| 12. The lessons assumed a different cultural background to mine | 1 | 2 | 3 | 4 | V14 | 20 |
| 13. The lessons are acceptable to my cultural group | 1 | 2 | 3 | 4 | V15 | 21 |
| 14. The lessons are suitable for adult learners | 1 | 2 | 3 | 4 | V16 | 22 |
| 15. The way in which concepts were presented allowed me to develop a deeper understanding | 1 | 2 | 3 | 4 | V17 | 23 |
| 16. The way in which the learning material was presented required me to memorise **meaningless** definitions and theorems | 1 | 2 | 3 | 4 | V18 | 24 |

17. The **screen displays** are:

| | Always | Sometimes | Never | | |
|---|---|---|---|---|---|
| Uncluttered | 1 | 2 | 3 | V19 | 25 |
| Neat | 1 | 2 | 3 | V20 | 26 |
| Too full | 1 | 2 | 3 | V21 | 27 |
| Consistent | 1 | 2 | 3 | V22 | 28 |
| Artistically appealing | 1 | 2 | 3 | V23 | 29 |
| Helpful in attracting and maintaining attention | 1 | 2 | 3 | V24 | 30 |

For office use

18. Consider the overall **text layout**.

| | Yes | No | | |
|---|---|---|---|---|
| It is easy to read | 1 | 2 | V25 | 31 |
| There is too much text on one screen | 1 | 2 | V26 | 32 |
| It is attractive | 1 | 2 | V27 | 33 |
| It is helpful in focusing attention | 1 | 2 | V28 | 34 |
| It is the same as reading text in a text book | 1 | 2 | V29 | 35 |

19. Consider the overall **use of colour**.

| | | Yes | No | | |
|---|---|---|---|---|---|
| (a) | It is consistent | 1 | 2 | V30 | 36 |
| (b) | Some colour combinations are difficult to distinguish | 1 | 2 | V31 | 37 |
| (c) | It is effective in focusing attention | 1 | 2 | V32 | 38 |
| (d) | Some colour conventions make me uncomfortable, e.g. red for incorrect answers | 1 | 2 | V33 | 39 |
| (e) | Too many colours are used | 1 | 2 | V34 | 40 |

If YES for (b), which colour combinations were difficult to distinguish?

_____ V35 41-42

_____ V36 43-44

_____ V37 45-46

If YES for (d), which colour conventions were uncomfortable for you?

_____ V38 47-48

_____ V39 49-50

_____ V40 51-52

For office use

20. The graphics (pictures, diagrams, illustrations, arrows, boxes) helped me to understand the content.

| Yes | No | Sometimes |
|---|---|---|
| 1 | 2 | 3 |

V41 [ ] 53

21. The "egg-man" character is:

| | Yes | No | | |
|---|---|---|---|---|
| Amusing | 1 | 2 | V42 [ ] | 54 |
| Childish | 1 | 2 | V43 [ ] | 55 |
| Offensive to my culture | 1 | 2 | V44 [ ] | 56 |
| Useful in breaking up the text | 1 | 2 | V45 [ ] | 57 |
| Useful in providing light relief | 1 | 2 | V46 [ ] | 58 |

22. The white rabbit character is:

| | Yes | No | | |
|---|---|---|---|---|
| Amusing | 1 | 2 | V47 [ ] | 59 |
| Childish | 1 | 2 | V48 [ ] | 60 |
| Offensive to my culture | 1 | 2 | V49 [ ] | 61 |
| Useful in breaking up the text | 1 | 2 | V50 [ ] | 62 |
| Useful in providing light relief | 1 | 2 | V51 [ ] | 63 |

For office use

Consider the movement within the lessons (navigation).

| | | Always | Sometimes | Never | |
|---|---|---|---|---|---|
| 23. | The directions for lesson control are clearly stated | 1 | 2 | 3 | V52 [ ] 64 |
| 24. | The icons are easy to use | 1 | 2 | 3 | V53 [ ] 65 |
| 25. | I experienced problems in selecting a topic from the menus | 1 | 2 | 3 | V54 [ ] 66 |
| 26. | It is easy to see which menu levels have been completed | 1 | 2 | 3 | V55 [ ] 67 |
| 27. | The Main Menus and sub-menus disoriented me | 1 | 2 | 3 | V56 [ ] 68 |

Questions 23 to 27:
If you experienced problems, please explain:

_____ V57 [ ][ ] 69-70

_____ V58 [ ][ ] 71-72

_____ V59 [ ][ ] 73-74

28. I found the following icons:

| | Useful | Confusing | Unnecessary | |
|---|---|---|---|---|
| BACK ← | 1 | 2 | 3 | V60 [ ] 75 |
| REPLAY F2 | 1 | 2 | 3 | V61 [ ] 76 |
| GLOSSARY F3 | 1 | 2 | 3 | V62 [ ] 77 |
| WHERE AM I? F4 | 1 | 2 | 3 | V63 [ ] 78 |
| REPEAT QUESTIONS (where applicable) | 1 | 2 | 3 | V64 [ ] 79 |
| PRESS F8 OR CLICK HERE FOR DEFINITION | 1 | 2 | 3 | V65 [ ] 80 |

For office use

| | |
|---|---|
| *29. Respondent number* | *V66* [ ][ ][ ][ ] *1-4* |
| *30. Card number* | *V67* [*0*][*2*] *5-6* |
| *31. Repetition number* | *V68* [ ] *7* |

32. I found the **level** of English usage in the computer lessons to be:
(Circle **only one** number.)

| Elementary | Intermediate | Advanced |
|---|---|---|
| 1 | 2 | 3 |

V69 [ ] 8

33. I found the **vocabulary** used in the computer lessons to be:
(Circle **only one** number.)

| Simple | Suitable | Advanced |
|---|---|---|
| 1 | 2 | 3 |

V70 [ ] 9

34. The lessons are free from vague and ambiguous language.

| | Yes | No |
|---|---|---|
| 1. Probability I | 1 | 2 |
| 2. Random variables | 1 | 2 |

V71 [ ] 10
V72 [ ] 11

35. Terms and concepts are clearly defined.

| Always | Mostly | Never |
|---|---|---|
| 1 | 2 | 3 |

V73 [ ] 12

36. The number of questions/exercises provided is:
(Circle **only one** number.)

| Not enough | Adequate | Too many |
|---|---|---|
| 1 | 2 | 3 |

V74 [ ] 13

For office use

37. Instructions on how to answer each question are clear. (Circle **only one** number.)

| Always | Sometimes | Never |
|---|---|---|
| 1 | 2 | 3 |

V75 [ ] 14

38. Rate the general difficulty level of the questions: (Circle **only one** number.)

| | |
|---|---|
| Too easy | 1 |
| Easy | 2 |
| Average | 3 |
| Difficult | 4 |
| Very difficult | 5 |

V76 [ ] 15

39. Answering the questions contributed towards my understanding of the topic. (Circle **only one** number.)

| Always | Sometimes | Never |
|---|---|---|
| 1 | 2 | 3 |

V77 [ ] 16

40. I learnt from the feedback after a wrong answer. (Circle **only one** number.)

| Always | Sometimes | Never |
|---|---|---|
| 1 | 2 | 3 |

V78 [ ] 17

41. I learnt some statistical concepts I didn't know before.

| | Yes | No |
|---|---|---|
| 1. Probability I | 1 | 2 |
| 2. Random variables | 1 | 2 |

V79 [ ] 18

V80 [ ] 19

For office use

42. In my opinion, these computer lessons:

| | Yes | No | | |
|---|---|---|---|---|
| Help to make Statistics more interesting | 1 | 2 | V81 | 20 |
| Help to make Statistics more understandable | 1 | 2 | V82 | 21 |

43. I found the lessons to be:
(You may circle **more than one** number.)

| | | | |
|---|---|---|---|
| Enjoyable | 1 | V83 | 22 |
| Interesting | 2 | V84 | 23 |
| Motivating | 3 | V85 | 24 |
| Challenging | 4 | V86 | 25 |
| Frustrating | 5 | V87 | 26 |
| Boring | 6 | V88 | 27 |
| Exhausting | 7 | V89 | 28 |
| A waste of time | 8 | V90 | 29 |
| Nerve-wracking | 9 | V91 | 30 |

44. Group or individual work:
(Circle **only one** number.)

| | | | |
|---|---|---|---|
| I liked working alone at the computer | 1 | V92 | 31 |
| I would prefer to do these lessons in a group | 2 | | |

For office use

Please indicate your level of agreement with each of the following statements by circling a number.

| | | Strongly agree | Agree | Dis-agree | Strongly disagree | |
|---|---|---|---|---|---|---|
| 45. | I felt confident interacting with a computer | 1 | 2 | 3 | 4 | V93 [ ] 32 |
| 46. | I felt as if I was having a conversation with someone | 1 | 2 | 3 | 4 | V94 [ ] 33 |
| 47. | I felt that I was an active learner | 1 | 2 | 3 | 4 | V95 [ ] 34 |
| 48. | I enjoyed working at my own pace | 1 | 2 | 3 | 4 | V96 [ ] 35 |

49. I found the tone of the lessons:
(You may circle more than one number.)

| | | |
|---|---|---|
| Patronising | 1 | V97 [ ] 36 |
| Friendly | 2 | V98 [ ] 37 |
| Conversational | 3 | V99 [ ] 38 |
| Childish | 4 | V100 [ ] 39 |
| Relaxed | 5 | V101 [ ] 40 |
| Academic | 6 | V102 [ ] 41 |

50. I would recommend these computer lessons to other students.

| Yes | No | Unsure | |
|---|---|---|---|
| 1 | 2 | 3 | V103 [ ] 42 |

51. I would like to work through the lessons again in my own time.

| | Yes | No | |
|---|---|---|---|
| 1. Probability I | 1 | 2 | V104 [ ] 43 |
| 2. Random variables | 1 | 2 | V105 [ ] 44 |

For office use

52. How would you rate these computer-assisted Statistics lessons?
(Circle **only one** number.)

| | |
|---|---|
| Very poor | 1 |
| Poor | 2 |
| Average | 3 |
| Good | 4 |
| Excellent | 5 |

V106 [ ] 45

53. With respect to Statistics, put the following activities in order of your preference, where 1 is your favourite and 5 is your least favourite.

| | Rank 1 - 5 | | |
|---|---|---|---|
| Attend a lecture | | V107 | 46 |
| Study a textbook or study guide | | V108 | 47 |
| Listen to an audio tape | | V109 | 48 |
| Watch a video | | V110 | 49 |
| Do a computer-assisted lesson | | V111 | 50 |

**Section 3: Give us your opinions**

For office use

54. What did you like best about these computer lessons?

V112 ☐☐ 51-52
V113 ☐☐ 53-54
V114 ☐☐ 55-56
V115 ☐☐ 57-58

55. What did you like least about the lessons?

V116 ☐☐ 59-60
V117 ☐☐ 61-62
V118 ☐☐ 63-64
V119 ☐☐ 65-66

56. What suggestions would you make to improve the lessons?

V120 ☐☐ 67-68
V121 ☐☐ 69-70
V122 ☐☐ 71-72
V123 ☐☐ 73-74

*Thank you for helping us to improve these lessons*

# Appendix G

# Error Log

## CAI LESSONS IN STATISTICS
## LIST OF ERRORS AND PROBLEMS

(Look out for typing errors, content errors and technical hitches, such as correct answers being refected, incorrect answers being accepted, program “hanging” etc.)

**LESSON: “Random Variables”**

| Screen number | Details of error/problem |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

## SPECIFIC POINTS TO LOOK OUT FOR

(Please give the screen number where applicable)

| | "Probability" | "Random Variables" |
|---|---|---|
| 1. Clear statement of aims on f0010?<br>If not, why not? | | |
| 2. Any vague/ ambiguous language? | | |
| 3. Amount of mathematical background assumed? | | |

| | | |
|---|---|---|
| 4. English / European cultural background a problem? | | |
| 5. Length of time taken to complete lesson: | | |

## Appendix H

## Telephone Interview Schedule

QUESTION 1: COMPUTER LITERACY

a) How frequently do you use a computer?

---

b) For how long have you been using a computer?

---

c) For what purpose do you use a computer?

---

---

QUESTION 2: AVAILABLE HARDWARE and SOFTWARE

Computer at home? Yes No Computer at work? Yes No

Screen: colour? Yes No Resolution: CGA EGA VGA SVGA

Mouse? Yes No Sound card? Yes No

Windows? Yes No

Disk drives? Floppy: HD DD Stiffy: HD DD CD-ROM?

Yes No

QUESTION 3: LENGTH OF TUTORIALS

---

QUESTION 4:

a) Have you since bought the CATs for use on your own computer?

---

b) If not, do you intend to buy them, or will you go and use the Unisa computer lab?

---

QUESTION 5:

Do you think working through the CATs will help with your revision before the exam?

---

QUESTION 6:
Any other comments:

---

---

**Interview Schedule for Telephone Interviews: Responses (n=12)**

QUESTION 1: COMPUTER LITERACY

a) How frequently do you use a computer?

| | | | |
|---|---|---|---|
| Daily: | 92% | Once a month: | 8% |

b) For how long have you been using a computer?

| | | | |
|---|---|---|---|
| Less than 5 years: | 58% | More than 7 years: | 42% |

c) For what purpose do you use a computer?

Word processing, spreadsheets, databases, electronic communication, CAI, games, computer science programming, presentations, flowcharting, project management tools.

---

QUESTION 2: AVAILABLE HARDWARE and SOFTWARE

| | Yes | No | | Yes | No |
|---|---|---|---|---|---|
| Computer at home? | 58% | 42% | Computer at work? | 83% | 17% |
| Screen: colour? | 92% | 8% | Resolution: VGA: | 50% | SVGA: 42% none: 8% |
| Mouse? | 92% | 8% | Sound card: | 42% | |
| Windows? | 92% | 8% | | | |
| Disk drives? | Floppy (HD): 50% | | Stiffy (HD): 92% | CD-ROM: 16% | |

---

QUESTION 3: LENGTH OF TUTORIALS

Adequate, acceptable

---

QUESTION 4:

a) Have you since bought the CATs for use on your own computer?

Only one student has bought them so far

b) If not, do you intend to buy them, or will you go and use the Unisa computer lab?

Intend to buy: 42% Unisa lab: 33%

---

QUESTION 5:

Do you think working through the CATs will help with your revision before the exam?

Unanimous agreement: 100%

---

QUESTION 6:

More examples; more problems; user-friendly; overview of the work; easy to follow; graphics very helpful; helpful in imparting basic concepts; more things possible than with written text; very good as a start; would recommend to other

students; graphics enhanced the lessons; should be incorporated as part of the registration package; easy to use in conjunction with study guide; good for home use; enjoyable; enjoyed the use of humour; feedback was helpful.

# Appendix I

# Reports of Peer Reviewers

**This Appendix not published on the Web**