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.

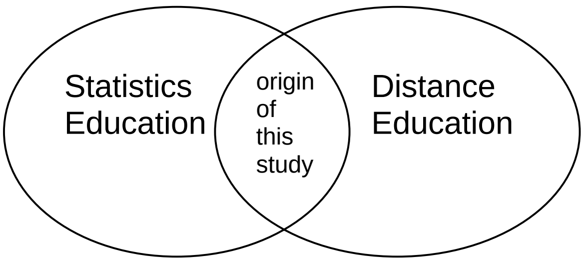

Figure 2.1 The origin of this study

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.

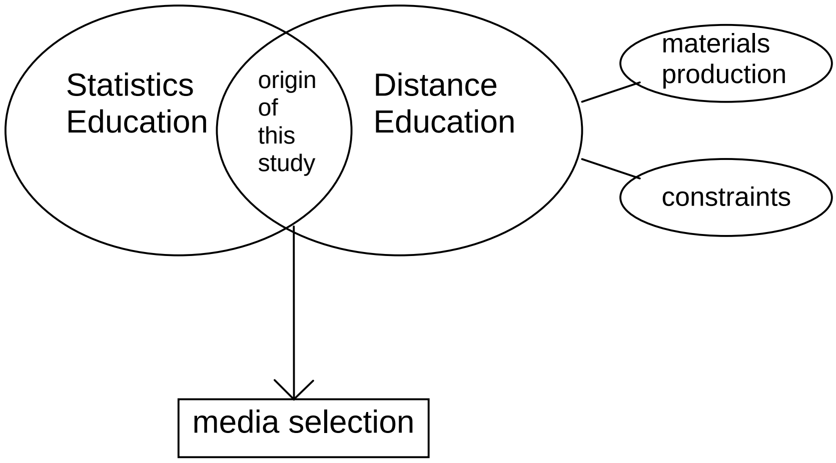

Figure 2.2 Issues which shaped this study

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.

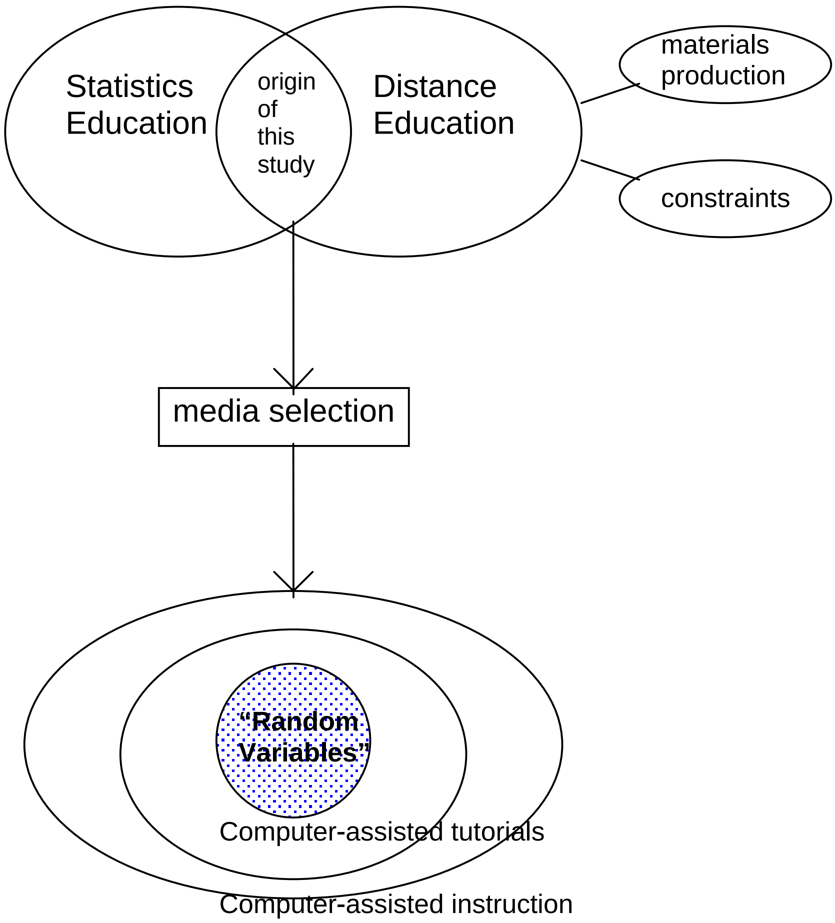

Figure 2.3 The placement of this study in the field

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:

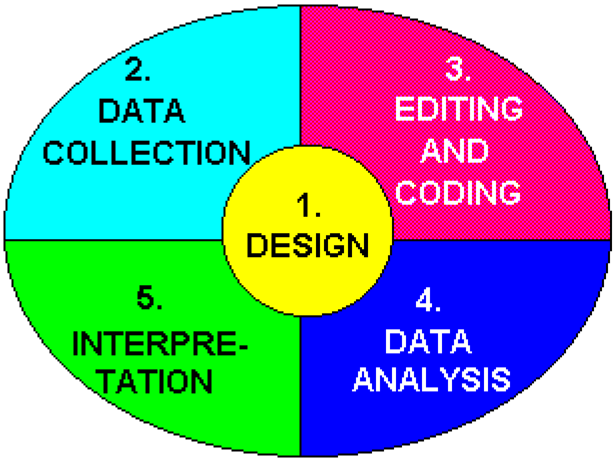

Figure 2.4 The role of statistics in the research process

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.

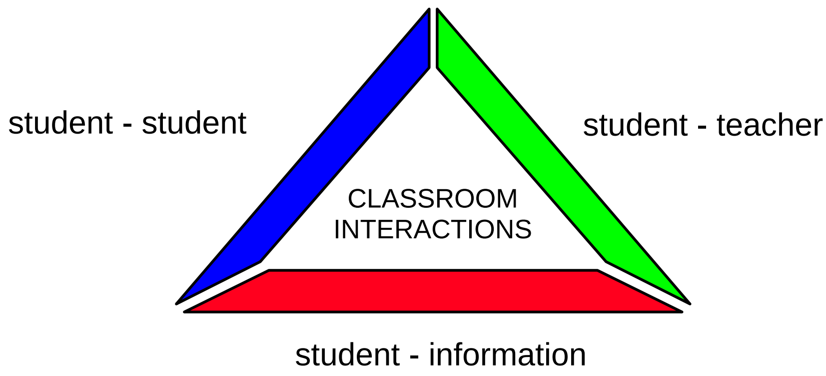

Figure 2.5 Classroom interactions

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.

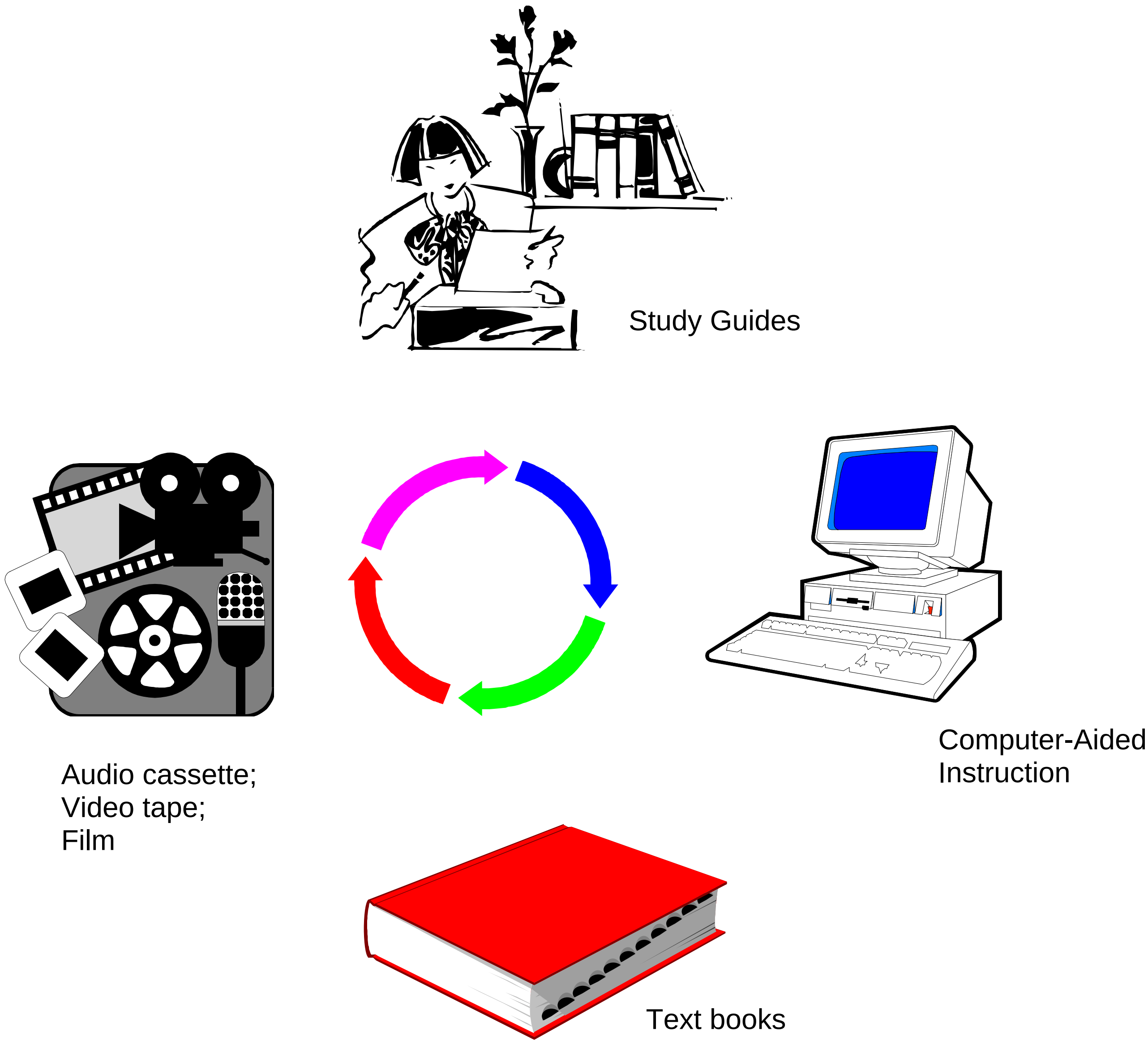

Figure 2.6 Instructional model using "multi media" in the sense of "multiple media"

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; the teaching approach; the "design".	lecture; discussion; question and answer; demonstration; discovery; experimentation; role play etc.
MEDIUM	
Description	**Examples**
the technology; the delivery mechanism.	text book; overhead projector; audio cassette; video tape; television; electronic mail; computer; 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.

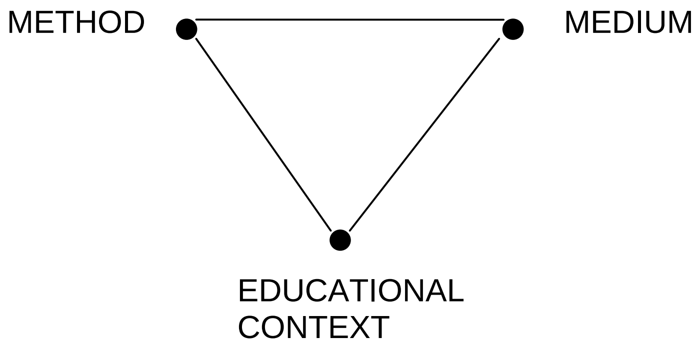

Figure 2.7 The fabric of the learning situation

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:

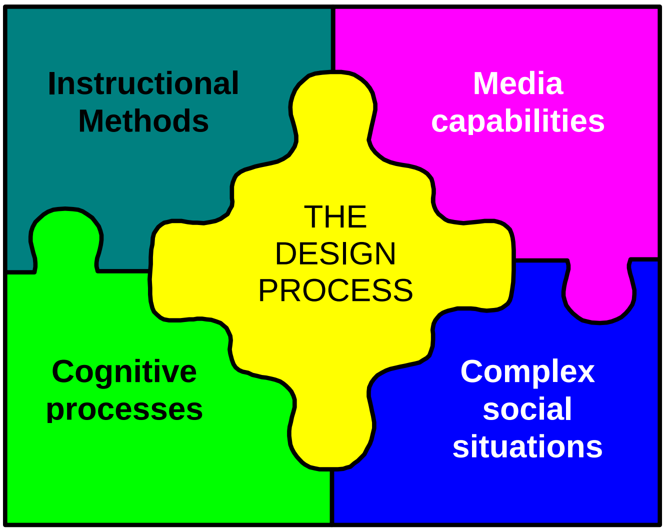

Figure 2.8 The design process

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.

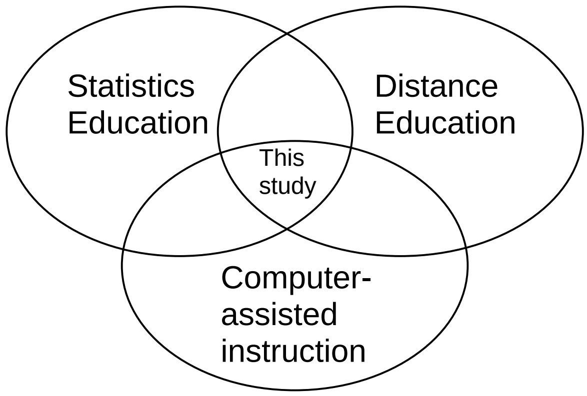

Figure 2.9 The placement of this study

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.