THE UNIVERSITY OF CALGARY

AN INTERACTIVE STATISTICAL TUTORING SYSTEM: A PROMISE FOR SOCIAL WORK EDUCATION

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

DEGREE OF MASTER OF SOCIAL WORK

FACULTY OF SOCIAL WORK

CALGARY, ALBERTA

APRIL, 1991

ISBN 0-315-66984-5

THE UNIVERSITY OF CALGARY

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "An Interactive Statistical Tutoring System: A Promise for Social Work Education" submitted by Jackie D. Sieppert in partial fulfillment of the requirements for the degree of Master of Social Work.

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ABSTRACT

Social work educators are currently faced with multiple and competing demands placed upon them by senior administration, teaching responsibilities and concern for students. More often than not educators are faced with the dilemma of balancing dwindling resources and exploding class sizes. However, educators remain responsible for providing quality instruction to their students. As a result social work education is frequently compromised in attempting to provide students the utmost in learning. At times traditional methods of instruction do not lend themself well to teaching social work students, suggesting the need to explore alternative modes of tutelage.

This thesis discusses the relative merits of one of these alternative methods of instruction with regard to the area of introductory statistics.. Deficiencies in traditional statistical training techniques have resulted in social workers who are ill equipped to conduct professional social work practice. Therefore, it can be suggested that traditional methods of statistical instruction are ineffective in teaching social work students. For this reason social work educators must explore ways to correct the deficiencies of present statistical instruction. Based on this premise the thesis had the following objectives.

Objective 1:

To establish the current state of statistical instruction in social work.

From a review of the literature this thesis shows that current modes of instruction result in social workers who view statistics negatively, who are unable to adequately utilize others' research findings, and who are ill equipped to complete statistical analyses as part of practice. For these reasons social work must explore alternative methods of teaching statistics.

Objective 2:

To develop a prototype interactive tutoring system (ITS) for statistics.

The second purpose of this thesis was to demonstrate the benefits of information technology, or more specifically computer assisted instruction, as an aid to traditional methods of teaching statistics. As CAI is relatively new to the educational process in social work, however, examples of CAI are extremely limited. Therefore, the thesis focused on the development of a prototype interactive tutoring system (ITS) that demonstrated the benefits of computer assisted instruction as a vehicle for strengthening statistical instruction in social work education.

This interactive tutoring system for statistics, called **HyperStat**, allowed the author to explore a supplemental method for teaching statitics to social workers. The findings indicated that social work educators <u>can</u> develop ITS applications. Moreover, CAI does offer training capacities that can strengthen the learning process. It offers the capability for a critical problem solving approach to instruction, for innovation and creativity in the instructional process, for building practice scenarios into the research process, for structuring individuated, adult styles of learning, and for meeting a mandate to introduce computer technology to social work education. For these reasons computer assisted instruction appears to address deficiencies found in traditional statistical education.

Findings of this study indicate directions for further research in social work. This includes research on how social work education can better prepare practitioners for engagin in empirical practice. Additional research is required to explore how CAI can benefit social work instruction and how to best develop CAI applications for social work education. Finally, additional research is required for pilot testing and validation of **HyperStat**.

ACKNOWLEDGEMENTS

In the submission of this thesis I wish to acknowledge the assistance and support of Dr. Floyd H. Bolitho whose boundless interest in exploring innovative uses of information technology proved contagious. As well, his insistence on the "big picture" and "transitions" provided frequent direction in the development of this thesis. I also wish to thank Dr. Richard M. Grinnell, who encouraged my early interest in the areas of social work research and statistics, and who continues to provide counsel toward my professional development. Lastly, I must thank the faculty and staff of the Faculty of Social Work at the University of Calgary who have created such a supportive and flexible environment over the last three years.

I express special gratitude to my wife Shirley for her undying support and patience; and to my children for their affection and tolerance. Together they offered a sane refuge, at times when my career and education threatened to obscure what is really important in life.

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CHAPTER ONE

INTRODUCTION

BACKGROUND TO THE PRESENT STUDY

The profession of social work has experienced considerable evolution over the last two decades. Slowly, the face of our profession continues to change. The transformation of social work, however, appears to move most slowly in relation to the growth of our knowledge base. Social work has traditionally (and to a large extent still does today) relied upon knowledge derived from more traditional social sciences like psychology and sociology. A solid quantitative knowledge base for social work practice does not yet exist, even though the helping professions and the social sciences have contributed increasingly larger amounts of research findings over the last half century (Bloom & Fischer, 1982).

Still, however, professional social workers are increasingly faced with demands to prove the efficacy of their services. Simply stated, accountability has become a major issue for social work. Both practitioners and agencies are being asked to provide objective measures by which professional practice may be judged. On all levels the question has become "How effective is our service?" For example, which treatment principles have been proven correct, what interventions are effective, and how may we best help clients with special needs?

In the midst of these questions we find the social work practitioner. How is their everyday practice affected by the issue of accountability? It is maintained that the accountable professional must utilize knowledge and skills in becoming a "professionally reflective, self-evaluating, knowledgeable and developed social worker (Council on Social Work Education, 1982). Social work professionals need to learn the tools that will allow them to keep pace with this drive for accountability. In short, social workers must become effective consumers and disseminators of research knowledge (Grinnell & Siegel, 1988). This concept of the empirically based social worker, or scientist/practitioner, has in fact emerged as a dominant theme for professional social work practice.

Despite the move to scientifically based practice, however, evidence exists that suggests social workers remain unable to utilize an empirically based mode of practice. Researchers have concluded that social work practitioners are ill equipped to consume, produce or disseminate quantitatively based research. For example, Kirk & Fischer (1976) advise that practitioners have little exposure to research-based practice literature, and are generally unable to evaluate its methodological soundness or draw implications for practice. Siegel (1983) concurs, and states that practitioners typically are not conducting empirical studies of their interventions, using research findings in their practice, reading research articles, or assessing research findings critically.

It has been also been argued that most MSW practitioners probably do not possess even a minimal understanding of research terminology requisite to an informed utilization of research findings (Lawson & Berleman, 1982; Kirk & Fischer, 1976). Moreover, Witkin et al. (1980) found that MSW practitioners could not identify six common statistical symbols. If social workers are unable to utilize such tools, what are their capabilities for producing research? In answer to this question, Glisson (1983) states that only a small minority of social work articles are based on research. As well, those that are provide examples of the gross misapplication of applied statistics and inappropriate research design. Glisson therefore concludes that research and statistics education in social work is, in fact, questionable even on the doctoral level.

It is the focus on the statistical education of a social worker that forms the background for this thesis. If, as the literature proposes, social workers are inadequately prepared to conduct empirically based practice, where does the root of the problem lie? Inevitably, one must look back to the education of the social worker. It is from our formal and informal education that both attitudes and skills flow. Therefore, it is the educational process that must be critically examined in view of the attitudes and inadequate skills that social workers display in regard to empirically based social work.

The literature does suggest that the statistical training of social workers is deficient. Lawson & Berleman (1982) argue that "as educators we are decidedly unsure of how to integrate research/statistics into social work curricula". Moreover, Glisson & Fischer (1987) propose that social work educational programs have systematically ignored the importance of adequate statistical preparation for social workers. The result is that statistical training promises to enhance the concept of empirical practice, and yet the promise remains a hollow entity. This has occurred even though the profession is advancing toward a more empirically derived concept of practice.

Finally, there exists a growing dissatisfaction among both teachers and students regarding research. Ramachandran and De Sousa (1985) attribute this to traditional instruction methods, which are inflexible, authoritarian and based upon memory. Weinbach and Grinnell (1987) also argue that the traditional rote method of learning statistics is flawed. Students' lack of real conceptual understanding, based upon rote learning, quickly results in statistics being forgotten.

All of the above represent a series of effects that are the product of inadequate research and statistical training in social work. These effects include an inability to adequately review and critique social work research, and an inability to produce and disseminate social work research. What can social work education do to rectify this situation? It has been suggested that the above evidence demonstrates the need for an alternative approach to statistical instruction. Social work educators argue for a new mode of instruction based on innovative educational principles, such as an emphasis on problem-solving, creativity, and individuation of learning (Gitterman, 1988; Glisson & Fisher, 1987; Kraybill et al., 1982; Ramachandran & De Sousa, 1985).

THE STUDY INTENT

Statistics are intrinsic in the foundation for empirically based social work practice. Weinbach & Grinnell (1991) state that statistical procedures are based on rules for decision making that are directly relevant to effective social work practice. This premise is explained by the authors as follows:

> We emphasize that the study of statistics provides social work students with an understanding of the concepts underlying sound social work practice. It lends power and precision to professional social work decision making while at the same time it gives us a better understanding of how knowledge for practice decision making is generated and evaluated.

Despite these views, few areas of study involved in the training of a social worker engender as much debate, anxiety, fear, and resistance as the research course. In particular, the study of statistics prompts both confusion and disagreement among educators and students alike (Glisson & Fischer, 1987). When combined with evidence that suggests social workers do not possess the skills necessary for empirical practice, one is lead to question the source of such negative attitudes and lack of skills.

In the experience of the author the anxiety, confusion and antagonism toward statistics have all been regularly evident among social workers. Both students and practitioners approach statistics with a high level of stress and distrust. Moreover, many are immediately convinced that they are not "mathematically oriented", and are simply not capable of performing statistical analyses. Even when armed with the traditional statistics texts, formulas, and computers many appear to miss the strong link between the role of statistics and everyday practice.

Deficiencies in traditional statistical training techniques have resulted in social workers who are ill equipped to conduct professional social work practice. Therefore, it can be suggested that traditional methods of statistical instruction are ineffective in teaching social work students. For this reason social work educators must explore ways to correct the deficiencies of present statistical instruction. Based on this premise the thesis has the following objectives.

Objective 1:

To establish the current state of statistical instruction in social work.

From a review of the literature this thesis will show that current modes of instruction result in social workers who view statistics negatively, who are unable to adequately utilize others' research findings, and who are ill equipped to complete statistical analyses as part of practice. For these reasons social work must explore alternative methods of teaching statistics.

Objective 2:

To develop a prototype interactive tutoring system (ITS) for statistics.

The second purpose of this thesis is to demonstrate the benefits of information technology, or more specifically computer assisted instruction, as an aid to traditional methods of teaching statistics. As CAI is relatively new to the educational process in social work, however, examples of CAI are extremely limited. Therefore, the thesis will focus on the development of a prototype interactive tutoring system (ITS) that will demonstrate the benefits of computer assisted instruction as a vehicle for strengthening statistical instruction in social work education.

SIGNIFICANCE OF THE STUDY

The attitudes of social workers toward the use of statistics in social work has been described by the literature as negative and anxious. Perhaps more importantly, the literature also suggests that social work practitioners do not possess the capacities to adequately consume or produce statistical analyses as part of their professional practice. In view of these problems, the drive for an empirical base for social work is unquestionably compromised. If, as Weinbach and Grinnell (1991) argue, statistics provide social workers with an understanding of the concepts underlying sound social work practice, the lack of statistical comprehension must hinder their understanding of basic social work concepts. Moreover, lack of statistical capabilities must prevent social workers from developing an understanding of how knowledge for practice decision making is generated and evaluated. Ultimately, a solid development of the profession's knowledge base will fail to emerge, and social work may remain heavily dependant on the other social sciences for our own principles. In effect, without a sound statistical foundation, social work will be unable to establish its own accountability, its own identity.

The study aims to demonstrate the benefits of information technology, in the form of computer assisted instruction (CAI), as an aid to traditional methods of teaching statistics. Computer assisted instruction incorporates educational principles and tools that have been identified by social work educators as critical to successful teaching. Therefore, information gained from the study can offer insights into the issues relevant to the statistical training of social workers. It can generate ideas about particular strategies for the reshaping of traditional statistical instruction. It can explore the promise that CAI offers for non-linear thinking, creativity, individuation of learning and problem-solving. Moreover, information gained from the development of prototype software to tutor statistics may be used to determine the relevance and utility of such innovative principles for teaching statistics. Finally, the process of developing a prototype interactive tutoring system (ITS) designed to tutor statistics may offer educators useful techniques for developing alternative methodologies for the teaching process. Thus, the development of the prototype may offer social work an introductory look at a new tool of instruction. I feel that this tool offers much promise for strengthening the teaching of statistics, and may eventually promote statistical competency among social workers.

Once social workers do become more adept at statistical analyses, the knowledge generated by these analyses will be incorporated into the theory and practice base of human service practitioners. It is critical for practitioners to develop statistical competency and to be confident in its use. By possessing such skills they can not only work effectively in their own settings, but also be involved in the development and dissemination of a wider knowledge base. The result will be a stronger social work profession.

PRESENTATION OF THE THESIS

The next chapter, Chapter Two, presents a review of the literature significant to the instruction of statistics in social work education, with a particular focus on the debate regarding the nature and utility of statistics in social work, the problems and deficiencies of statistical instruction, the need for an alternative approach to statistical training, and educational principles for overcoming problems of statistical instruction. This review of the literature establishes the current state of statistical instruction within social work education and indicates the role that information technology, or more specifically computer assisted instruction, can play in enhancing statistical teaching.

Chapter Three explains the conceptual framework that underlies the development of a prototype interactive tutoring system (ITS) for statistics. It outlines the concept of computer assisted instruction, describes two innovative tools for CAI (called object oriented programming and *hypertext*) and describes the benefits and limitations of these tools for computer assisted instruction.

Chapter Four presents the structure utilized for developing the prototype statistical tutorial software. The need and intent of prototype hypertext statistical instruction software will be further defined. As well, the prototyping process will be detailed, including the purpose of the application, the selection of a substantive basis for the software, the selection of an application development software used to develop the prototype, and the design procedures utilized in the development of the prototype.

Chapter Five presents the conclusions drawn from the development of the prototype ITS for statistics. The value and utility of interactive tutoring systems, object oriented programming and hypertext for social work education will be discussed. Finally implications for social work education and, statistical training in particular, will be drawn from the prototyping experience.

CHAPTER TWO

THE RESEARCH PROBLEM: STATISTICS IN SOCIAL WORK EDUCATION

In this chapter we review literature significant to the instruction of statistics in social work education. In so doing we provide the theoretical background for this thesis and outline its relevance and contribution to social work knowledge and practice. We begin by considering the general field of research and statistics in social work education.

REVIEW OF THE LITERATURE

RESEARCH AS CORE CONTENT IN SOCIAL WORK EDUCATION

Social work has long debated the nature and purpose of its educational processes. Issues such as genercism vs. specialism, curriculum rigidity, the lack of feminist perspectives, and the role of empiricism are commonly debated in social work journals. Such concerns have combined to cloud the educational spectrum for social work. It has even been suggested that we depend on others to set our priorities, that we are plagued by self-doubt, and that we are unsure about what to include and what to leave out of the curriculum (Coulshed, 1988). In particular, the trend toward increased emphasis on research methods in social work education has engendered extensive debate. The profession is experiencing considerable confusion and conflict over both the presence and nature of the research content to be taught to social workers (Austin, 1978; Glisson, 1982; Hudson, 1982). In fact, it should be noted that the literature often combines the distinct areas of research methodology and statistical training, and debates their presence as one entity. In many of the references cited within this literature review the term "research" inherently includes both the presence of statistics, and training in the area of statistics.

Some social work educators contend that social work should abandon empirical research entirely, as it offers no utility for social work practice. These educators argue that the empirical process is contaminated by researcher subjectivity, an emphasis on statistical significance over substantive significance, and the practice of formulating hypotheses to conform to specific research methodologies (Heineman, 1981; Pieper, 1985). At the extreme, it has been stated that other social sciences have abandoned empirical research and that social work has benefitted little from a "long history" of empirical research (Pieper, 1985).

Other educators, such as Karger, argue that social work research attempts to impose an artificial, politically based methodology upon social work practice. Karger advises that scientific symbols and social work research are utilized to "enforce a division of labor - with its attendant status classifications. These symbols are manipulated to maintain and reproduce both the culture and hierarchy of the social work profession" (Karger, 1983). In essence, empiricism is a myth facilitated by the self-proclaimed elite of the social work profession - social work educators - in order to maintain their dominance over social work practice.

Despite the above arguments, however, the critical role of research in social work, and consequently in social work education, <u>***has***</u> been firmly established. The most influential source of this validation stems from the Council on Social Work Education (CSWE). CSWE is responsible for setting minimum educational standards for both BSW and MSW programs, and for accrediting social work curriculums. In sections 7.12, 7.13, and 7.14 of the latest of its Curriculum Policy Statements the CSWE asserts that students are to be taught practice skills applicable to any client system (Council on Social Work Education, 1982). The Curriculum Policy Statement states:

> It is essential, therefore, that all professional social workers have, in common, knowledge, values, and skills that are generally transferable from one setting, population group, geographic area, or problem to another.

The knowledge, values, and skills that form the premise of this statement are embodied in a logical, empirically based approach to social work. Practitioners are expected to consume, acquire, and disseminate knowledge for effective practice and for effective program development, implementation, and evaluation. The accountable professional, it is held, must utilize knowledge and skills in becoming " a professionally reflective, self-evaluating, knowledgeable and developed social worker (CSWE, 1982).

Social work curriculums thus define and manifest our profession's movement toward empirically based practice. If social work education is to fully prepare students to be effective, ethical practitioners the empirical foundation of research-based social work is critical. This premise is now generally agreed upon by numerous social work educators (Bloom & Fischer, 1982; Glisson & Fischer, 1987; Grinnell & Siegel, 1988; Hudson, 1982; Kolevzon, 1984; Rosen & Mutschler, 1982; Siegel 1983). These educators generally adhere to a philosophy that provides a new mandate for social work education. This mandate demands that:

> the ethical use of scientific inquiry be emphasized throughout the entire social work curriculum and that social work students be taught how to evaluate their practice effectiveness, how to generate new and useful knowledge for practice, and how to read and use research findings in their daily work (Grinnell, 1988).

If the concept of an empirically based, scientific practitioner is now generally accepted, why then does the debate regarding the role of research in social work persist?

The reason is that research education, and statistical instruction in particular, remain areas of concern for both instructors and students alike (Epstein, 1987; Glisson & Fischer, 1987; Ramachandran & De Sousa, 1985; Weinbach & Grinnell, 1987). Current methods of statistical instruction display difficulties and deficiencies that seriously impair the concept of the practitioner/researcher in social work (Glisson & Fischer, 1987). Social work education has failed to provide students with the empirical basis required for scientific practice (Glisson, 1983; Karger, 1984; Kraybill et al., 1982). In the following section we will review the obstacles identified in the literature that have led to this situation.

PROBLEMS AND DEFICIENCIES OF STATISTICAL INSTRUCTION

Even more intensive than the general debate over research in social work, is the conflict over the extent to which social work students should be trained in statistics as part of the research curriculum. Social work education displays a notable lack of consensus regarding the utility of statistical instruction.

Charles Cowger questions the value of current statistical training for social workers, based on the misinterpretation and misuse of significance tests utilized in the practice of social work research (Cowger, 1984). He argues that the use of statistical significance tests represents a ritualistic activity rather than a valid scientific method. Borrowing from debates in sociology, psychology, and education over the past two decades, it is asserted that an emphasis upon mathematical techniques becomes the ultimate objective, replacing the logic of science. The result is a propensity toward formulating hypotheses that are readily testable rather than hypotheses that are vital to the field. As well, common technical errors in the use of statistics, including the disregarding of random sampling requirements, multiple and continuous analysis of data, and inappropriate collapsing of data, potentially make statistics a corrupt and fallacious scientific method. Citing the following example from sociology, Cowger explains the potential misuse of statistics, again based on the fallacy of statistical significance tests:

> Significance tests were often interpreted as proof of hypotheses, and confusion reigned over what was theoretically significant and statistically significant, data were inappropriately manipulated to show statistical significance, and professional journals began to use positive tests of significance as a criterion for acceptance of research manuscripts (Cowger, 1984).

Other social work educators concur with Cowger. Heinemen (1981) states that social work somehow assumes that data is objective and distortion free, thereby relegating objectivity to an entity that may be defined by scientists within their own personal contexts. The result is that theories and concepts which do not lend themself to measurement operations cannot be successfully studied. Karger (1983) reiterates that statistics offer questionable utility, and should be abandoned, on the basis of infrequent utilization of research by practitioners, an "inability" of social work students to execute credible research, and a lack of resources within practice agencies to conduct studies. Finally, Pieper (1985) adds that statistical significance presides over substantive significance in social work, leading to the common practice of formulating hypotheses to fit particular empirical methods. She contends that social work depends upon correlative research for its foundation, which is flawed by inappropriate use of the inferential process and assumptions of causality.

A series of social work educators are stridently opposed to the proposition of abandoning statistics within social work. These educators argue that it is not the statistics within social work that are flawed. Rather, deficiencies and limitations in the statistical education of social work students conceal the utility that statistics offer social work practice (Glisson, 1985; Glisson & Fischer, 1987; Hudson, 1982; Rosenblatt & Kirk, 1981; Kraybill et al., 1982; Ramachandran & De Sousa, 1985; Siegel, 1983; Weinbach & Grinnell, 1987).

For example, Glisson (1985) counters Cowger's (1984) questioning of the value of current statistical procedures and training. He does recognize the prevalence of misuse and misinterpretation of statistics in social work education. He rejects, however, the premise that prevailing statistical practices are potentially corrupt and fallacious. Glisson suggests that the misuse and misinterpretation of statistical significance tests, which form the basis of Cowger's argument, are simply the result of inadequate education of social work students. It is held that appropriate training in scientific methodology, measurement, and statistics would enable social work students to avoid inappropriate application of statistical principles in their research endeavours.

Evidence for this premise can be found in a study of thirty-three doctoral program research curriculums in the United States. The study found that over half of the programs were currently teaching statistics at an ***elementary***, undergraduate level (Glisson, 1982). Glisson therefore concludes that:

> The fact that confusion exists among some researchers about these issues does not suggest that social work researchers should de-emphasize or abandon the use of significance tests, but suggests that they should be trained in their proper use and interpretation (Glisson, 1985).

A number of researchers have pointed to the fact that research and statistics are not treated as an integral component of the overall curriculum. Research and statistics courses instead tend to be isolated curricular options, tangential to the core curriculum (Aigner, 1984; Hudson, 1978; Kraybill et al., 1982). Lawson & Berleman (1982) argue that the issue of base knowledge and competence appears not to have been resolved at any level of social work education. Further, clarification of research competencies is critical for a logical sequential continuum of social work education. They conclude by saying that it is evident that "as educators we are decidedly unsure of how to integrate research/statistics into social work curricula".

It is this integration of research and practice education that becomes a particularly critical issue. Rosen and Mutschler (1982) compared BSW, MSW, PhD students and social work practitioners. The study found that BSW students and practitioners shared negative perceptions regarding the importance and validity of research. It is suggested that the negative attitudes of practitioners reflected the failure of social work curricula in integrating research into the realities of practice.

A 1979-80 study of the integration of research and practice in a graduate social work curriculum draws much the same conclusions. The study concluded that we need to continue to develop research concepts and methods of empirically based practice, so that they may expand our ability to apply research technology in the helping process. The author proposes that social work educators who hope to train students to objectify practice through measurable and observable behaviors must reconsider the complexities of practice. The thorough integration of research into practice is the key (Siegel, 1983).

Brown and Levitt (1978) also acknowledge the value of empirically based eduction for social workers. They stress, however, that the tools of research need to be further built into practice, a process that is rarely emphasized. When research is taught the foundations of practice are commonly ignored. More systematic practice teaching, rather than research courses, they argue, is urgently required. Walter Hudson agrees with this call for the marriage of research and practice. He, however, insists that the answer lies in idiographic research training for practice workers. Hudson asserts that this training must consist of well designed research courses intended to integrate practice issues, rather than practice courses which may de-emphasize research and statistical principles (Hudson, 1978). In effect, Hudson later states, there need not be an ideological rift between research and practice in social work (Hudson, 1982).

Glisson & Fischer (1987), though, go further and propose that social work educational programs have systematically ignored the importance of adequate statistical preparation for social workers. This has occurred even though the profession is advancing toward a more empirically derived concept of practice. The authors recognize this lack of integration and reflect upon its meaning for the scientist/practitioner:

> Yet without adequate statistical training, those themes have a hollow sound, paying only lip service to an important, but unattainable ideal. In order to implement either model, students must be prepared to understand, both in their reading of the social science research literature and in their own conducting of empirical research, the range of statistical practices commonly applied in the social and behavioral sciences.

In addition to a lack of consensus regarding the value of statistics, and their lack of integration into curricula, however, are other deficiencies in current educational models. These include the outdated lecture/blackboard approach to teaching and technological illiteracy.

Ramachandran and De Sousa (1985) contend that there exists a growing dissatisfaction among both teachers and students regarding research. The authors attribute this to traditional instruction methods, which are inflexible, authoritarian and based upon memory. Much more useful, it is argued, is the encouragement of the problem solving approach, which stresses creativity and innovation. The true essence of teaching the research process, it is advised, is vastly different than simply lecturing to students:

> What the teacher often communicates is abstract ideas shorn of their relationship to the concrete reality out of which they were gleaned. This is mere information and is hardly real knowledge, leave alone becoming real wisdom. It only becomes knowledge when the concrete situation from which it grew is also conveyed. In other words, the very process through which it was gained - the situation, the questioning and grappling with the situation, and finally, the abstraction or articulation of the meaning of the situation for the author must be conveyed.

Other social work educators uphold the essential nature of the problem solving process for social workers (Epstein, 1987; Gitterman, 1988; Grinnell & Siegel, 1988; Kolevzon, 1984). Gitterman (1988) utilizes a framework of bridging the "abstract and real worlds". By this framework he reminds us that there exists an indispensable distinction between students' "knowing that" (having facts and information) and "knowing how" (using facts and information). The result is that instructors must engender in students an inquiring, creative posture that combines with gentle skepticism.

Kraybill, et al., (1982) propose a similar model of research instruction. They state that a major obstacle in cultivating competent social work researchers lies in students' inexperience with skeptical and critical thinking. It is the responsibility of social work education to foster this skepticism. This is not achieved through the traditional course structure - that of the lecture. Rather, it is achieved by teaching students to ask "ugly" questions, by demystifying research, and by promoting critical consumption of research.

It has also been noted that statistics courses have always proven to be major hurdles for social work students. Weinbach and Grinnell (1987) argue that the traditional rote method of learning statistics is flawed. Students' lack of real conceptual understanding, based upon rote learning, quickly results in statistics being forgotten.

> There is, we think, a danger in teaching practices that present a concept only once and then assume student mastery of it. We feel that the only way to understand statistical concepts is through repetition; our discussions with other statistics instructors confirm this impression .... The fact that many of us learned statistical procedures by rote rather than by gaining a real conceptual understanding of them is well known to instructors who watch students actually attempting to apply statistics two or three semesters after they have completed the basic stat course (Weinbach & Grinnell, 1987).

In addition, many statistics courses only offer instruction in the use of packaged statistical computer programs. Such courses offer little value to social work students, as they fail to facilitate true understanding of statistical procedures (Glisson, 1982).

> However, many courses are being offered which teach only the application of these packaged programs; they offer no material which facilitates the understanding of the methodology. Such a black-box approach to learning advanced quantitative methods is far from desirable. This approach limits the understanding and interpretation of results and constrains the student to fit research thinking into categories defined by particular packaged programs.

It is this limited vision of the role of technology in social work education that defines a final limitation of current statistical instruction. Quite simply, computer illiteracy negates the true potential of statistical training. LaMendola (1987) states that the use of computer technology in social work has traditionally been limited to the use of packaged statistical software for quantitative analysis. He argues that such utilization of information technology is short-sighted, as information technology offers many possibilities in assisting historical research, bibliographic studies, qualitative research, case studies, ethnographic studies, and as teaching aids. Perhaps as importantly, information technology offers the student a metaphysical tool for self-exploration, discovering not only their own identity, but the identity of social work as well. In effect, the role of computers should be extended to much more than the pre-defined analysis of statistics. Computers can be valuable additions not only in social work, but in the teaching of social work.

Other social work educators also recognize the limitations created by computer illiteracy on the part of social work students. For example, Glisson and Fischer (1987) agree that computer literacy is an integral part of statistical training. Basic statistics can be calculated by hand, but the sophistication required for advanced statistics and the growing need to master computer applications point to the critical nature of building computer skills into the statistical training of social work students.

It has been noted that the current marriage of statistics with very limited exposure to computer course work poses difficulties for students and educators alike. Without a concurrent exposure to computers and the diversity of computer applications, training in such areas as statistics is only partially successful. Typically students experience unpleasant associations toward statistics in general, and when mated with computer technology a compounded, phobic-like reaction occurs. Together, these reactions ensure that both statistical competency and computer literacy suffer (Parker et al., 1987).

Finally, Born (1987) asserts that traditional views among professionals and educators see computers only as "number crunchers". This limited vision is a product of a lack of expertise on the part of both professionals and social work educators. The result is that social work students are not receiving adequate exposure and experience to information technology, and are subject to misconceptions that prejudice them against both empirically based practice and information technology. This resistance results in their preparation as professionals being compromised.

We have identified a number of problems and deficiencies in current statistical instruction. These include a lack of consensus regarding the need and nature of statistics training, the lack of integration of research and statistics into the overall curriculum, the persistence of the lecture/blackboard approach to teaching, and the failure to promote connections between statistical instruction and computer literacy for social work students. What, then, are the results of these deficiencies? Or perhaps more precisely, what evidence do we have that these problems in statistical instruction really exist? In the following section we will review the literature that identifies the need for an alternative approach to teaching statistics in social work.

THE NEED FOR AN ALTERNATIVE APPROACH TO STATISTICAL INSTRUCTION

The products of deficiencies in statistical instruction emerge in many forms within social work. The first and most obvious of these effects are the attitudes that students, practitioners, and to some degree instructors, display toward research in general, and statistics in particular. Ramachandran and De Sousa (1985) express a growing dissatisfaction with the apparent lack of interest on the part of both teachers and students toward research within social work. Likewise, Weinbach & Grinnell (1987) recognize that those who write statistics books - social work educators - are often more adept at illustrating sophisticated mathematical notations than they are at providing insight into fundamental statistical principles. The result, the authors suggest, is that this interest in mathematical prowess, rather than in true teaching capacities, precludes students from developing any kind of interest in learning statistics. Finally, Epstein (1987) proposes that many research educators teach research as though they are "bringing religion to the primitives". Through ritualistic emphasis upon ontologically meaningless research icons, such as the calculation of Chi-square, instructors fail to address the real and appropriate practice concerns of students. Instead of demystifying research and statistics some instructors prefer to focus on debunking research. They concentrate on exploring rifts between research and practice priorities. Such a mixture of cynicism and negative postulating, Epstein argues, leaves students with similar cynicism and demoralization toward research and statistics.

A number of studies regarding student and practitioner attitudes toward research support this view. Rosenblatt & Kirk (1981) compared BSW, MSW, and PhD students and concluded that the importance and usefulness of research was rated higher at each progressive level of education. Students perceptions regarding the validity of research, however, failed to increase with higher levels of education. Rosen & Mutschler (1982) included practitioners in a replication of this study. They discovered that students and practitioners were significantly less positive toward research than graduate students. It was suggested that these negative attitudes reflect the failure of the social work research curriculum in addressing the realities of social work practice.

In effect, the social work research curriculum fails to engage social work students on a level that will engender positive attitudes toward research. Epstein (1987) summarizes the typical reaction of students to research and statistics courses in the following manner:

> No other part of the social work curriculum has been so consistently received by students with as much groaning, moaning, eye-rolling, bad-mouthing, hyperventilation and waiver-strategizing as the research courses.

These views have been both quantitatively and qualitatively documented. Lawson & Berleman (1982) report that in a survey of accredited undergraduate social work programs both program directors and instructors perceived student attitudes toward statistics as clearly negative. In fact, instructors viewed research as being negatively perceived by 53% of social work students and statistics as being negatively perceived by 82% of them. It is not surprising, the authors suggest, that only an estimated 6% of students took research/statistics courses beyond core requirements. The final result is that teaching research and statistics becomes an formidable task for any social work teacher.

In 1979-1980 a study examined the attitudes of 148 first year master's degree students toward a curriculum that integrated research into practice courses. It was found that the students failed to view research and practice as strongly integrated in the curriculum. More importantly, however, studying research did not make students more enthusiastic toward the use of research in social work. Rather, an overall increase in negative attitudes toward research was found across several sections of practice-research courses. (Siegel, 1983).

This pattern extends as students become practitioners. Two decades ago Rosenblatt (1968) concluded that practitioners fail to view research as capable of providing answers or guidelines to practice-relevant concerns. Kirk et al., (1976) later expanded upon this premise. They advise that practitioners display a less than desirable level of knowledge, interest, and utilization of research, suggesting a failure of social work education to instill in practitioners the attitudes and knowledge that are conducive to research utilization. Lawson & Berleman (1982) state that both social work students and practitioners have found the study of research and its applicability to practice as being either difficult to appreciate or of limited utility.

Finally, Kirk (1979) possibly provides the best summary of the relationship between the attitudes of social workers and the research process. He concludes:

> They [social workers] profess a high regard for research, but they don't like to study research, they seldom use research studies in their professional work to improve their skills; their professional reading is not research oriented; they are not likely to conduct research after leaving school and they have considerable difficulty accepting research with negative findings.

These perspectives eventually translate into other effects, again generated by inadequate research and statistical training. The literature suggests that the average social worker is inadequately equipped to consume, produce or disseminate quantitatively based research. For example, Taylor (1990) argues that educational curriculums not only fail to make students statistically competent, but they also fail to make social workers numerate. By this Taylor refers to the ability to grasp the quantitative aspects of practice, and to put that knowledge to use in problem-posing and problem-solving capacities. It is proposed that social work education must focus on fundamentals, in order that social workers may learn to use quantitative analyses in their day-to-day practice.

Such views have been previously stated. Kirk et al., (1976) advise that practitioners have little exposure to research-based practice literature, and are generally unable to evaluate its methodological soundness or draw implications for practice. Siegel (1983) concurs, and states that practitioners typically are not conducting empirical studies of their interventions, using research findings in their practice, reading research articles, or assessing research findings critically.

Other evidence of these incapacities does exist. For example, it has been argued that most MSW practitioners probably do not possess even a minimal understanding of research terminology requisite to an informed utilization of research findings (Lawson & Berleman, 1982; Stuart & Fischer, 1976). Witkin et al. (1980) in a survey of 128 social workers who possessed either MSW or BA degrees found that neither MSW's nor BA's could identify six common statistical symbols. If social workers are unable to utilize such tools, what are their capabilities for producing research? Glisson (1982) conducted a study of the perceptions of thirty-seven chairpersons of social work doctoral programs.

He found that these chairpersons rated their own graduates as more than adequately trained in research and statistical skills. On a national level, they rated social work doctoral graduates' research and statistical skills between less than adequate and adequate. Glisson states that these perceptions of general student competency are contradicted by the evidence found in social work journals. He notes that only a small minority of social work articles are based on research. Moreover, those that are provide examples of the gross misapplication of applied statistics and inappropriate research design. Glisson therefore concludes that research/statistics education is in fact questionable, even on the doctoral level.

The evidence presented by the quality of social work publications is the final confirmation of the failure of social work instruction. Glisson (1983) conducted a review of all the articles published over a six year period in five prominent social work journals. These journals included Social Work, Social Service Review, Journal of Social Work Education, Journal of Social Service Research, and Social Work Research and Abstracts. He found that only 44% of the articles reported or summarized the results of empirical research. Glisson (1983) also compared the prevalence of empirically-based articles in American Psychological Association publications with these publications in social work. He discovered that over 90% of the articles published in five APA journals reported or summarized the results of empirical research. This was more than double the percentage of empirical articles found in social work journals. Finally, Glisson found that of more than one thousand articles in these social work journals only ninety-five, or 9.5%, attempted any type of quantitative analysis.

Glisson & Fischer (1987) later follow up on this premise in suggesting that the elementary level of statistical training found in doctoral curricula and statistical analyses reported in social work journals are inadequate. They argue that both these areas are hindered by an overall lack of knowledge of analytic techniques. This lack of knowledge restricts the type of questions and variables that social workers can address and results in the misapplication or misinterpretation of statistical analyses. Perhaps most importantly, social workers are left dependent upon others' interpretations and critiques of results. Social workers without improved statistical training must therefore rely on other professions for research related to their own areas of expertise. This thought is substantiated by Karger (1983) and Kraybill et al. (1982), who note that even the objective of training social workers to be informed consumers of research is not being met.

We have identified a series of effects that are the product of inadequate research and statistical training in social work. These effects include an inability to adequately review and critique social work research, an inability to produce and disseminate social work research, and an inability to utilize analytical/problem solving skills in either research or practice. What can social work education do to rectify this situation? It has been suggested that the above evidence demonstrates the need for an alternative approach to statistical instruction. Social work educators argue for a new mode of instruction based on innovative educational principles, such as an emphasis on problem-solving, creativity, and individuation of learning (Gitterman, 1988; Glisson & Fisher, 1987; Kraybill et al., 1982; Ramachandran & De Sousa, 1985). In the following section we will briefly review means of overcoming problems of statistical instruction.

EDUCATIONAL PRINCIPLES FOR OVERCOMING PROBLEMS OF STATISTICAL INSTRUCTION

A number of educational principles consistently emerge in any discussion of improving social work education in general, and statistics instruction in particular. The first and foremost of these is to focus education upon the fundamentals that underlie social work practice. In regard to statistics this means to focus on the foundations of quantitative analyses. Taylor (1990) notes that social work students may be inadequately prepared in the mathematics skills necessary for elementary statistics. He therefore calls for educators to provide opportunities for students to critically evaluate their quantitative knowledge and skills, and to apply them in problem-solving work within the context of professional practice. Other authors also emphasize the importance of teaching the basics of quantitative analysis. Once again both Weinbach & Grinnell (1987) argue that the traditional rote method of learning statistics is flawed. Along with Glisson & Fischer (1987) they argue that instructors must engender a true conceptual understanding of statistics. This can only be achieved by allowing a foundation of basic statistical principles to dominate as the core of learning in the research curriculum.

Epstein (1987) delineates a number of pedagogical principles that are believed to be associated with effective research teaching. All of these axioms, Epstein states, are designed to integrate, rather than to alienate, students into the research process. The principles are as follows:

1. Start Where the Students Are - Openly acknowledge the resistance of students, encourage an open and honest discussion of the negative attitudes, and stress the importance of a questioning frame of mind.
2. Let the Student Set the Pace - In order to decrease student anxiety and engage the maximum number of students, let them set the pace of instruction.

3. Link Assignment to Student Objectives and Concerns - Stress the integration of practice issues and concerns into research instruction. This includes partialization or logical sequencing of topics, working with real data, and encouraging the discussion of broader implications of the research process.
4. Respect Students and Their Innate Desire to Learn - Respect the student as an adult learner, and respond with possibilities for the individuation of learning.
5. Demystify But Do Not Trash - Make research concepts and techniques comprehensible without trivializing or debunking them.
6. Teach Statistics From the Standpoint of the Consumer - Focus not on ritualistic computation of statistics, but on the kinds of interpretive inferences one can and cannot make from statistical measures and the conditions under which they are and are not appropriately used.

The premise of integrating research into practice, through the development of problem solving capacities is also a key for many social work educators. Lawson & Berleman (1982) state that there is a definite need for teaching materials and techniques that integrate social work methods, research and statistics. Moreover, Kraybill et al. (1982) stress the significance of giving students the confidence and ability to ask good questions. To achieve this research must be demythologized, students must not feel intimidated by research, and they must be encouraged to utilize their intuition in developing a problem-solving posture. Gitterman agrees with the idea of promoting creativity and innovation in students. He points to the essential nature of questioning:

> Our task, therefore, is to help students break through theoretical and personal boundaries, and cultivate their natural curiosity and spontaneity. A willingness to risk, to learn from mistakes and to change are the "sine qua non" of creativity.

Merl Hokenstad Jr. (1984) suggests not only the integration of research and practice in social work education, but a focus upon experiential learning. This includes helping students to develop new ideas and practice strategies, test them, observe the results, and learn from the consequences. In such a framework instruction should involve an extensive use of laboratory exercises and field experiences to make learning as experiential as possible for the student. Kolevzon (1984) concurs, and stresses the critical nature of responding to the varied backgrounds and competencies of students by fostering individuation as an integral component of instruction. He argues that learning often takes place most effectively when:

> ... the subject is relevant to students and when the mode of instruction takes into account both the students' and the teachers' individual styles. Excessive pressures to conform rob the teaching-learning process of its vitality.

Ramachandran & De Sousa (1985) propose a number of instructional techniques that prevent the suppression of independent and creative thinking, a problem of research teaching. By this process, the authors suggest, the student should be exposed to experience in the field and made to grapple with a clear formulation of the research/practice problem. As well the student should be encouraged to view substantive issues and concerns through a process of reflection, re-thinking, searching, and discovery. Finally, research instruction should be depicted as a collection of different tools and techniques for experimenting and evaluating possible answers to social work questions. The strategy to accomplish these goals is to utilize a problem posing approach to instruction. Radically different from the lecture/blackboard approach to teaching, which stresses the memorization of information, the problem posing method attempts to generate a dynamic, interactive teaching process. It is a process very much based on Socratic principles of thought. As such the problem posing method involves five stages in the learning process; observation of previously abstract concepts in practice situations, description of what the student saw, heard and felt, student explanation of what they have experienced, hypothesizing of possible cause-effect relationships, and finally evaluation of the hypotheses generated by the student. If these steps are followed Ramachandran & De Sousa suggest that the student will develop an inquiring and innovative mind, the ability to question even the most sacred theories and conventional wisdom, and an intuitive-creative quality regarding research.

Finally, Glisson & Fischer (1987) also delineate principles critical to effective statistical instruction. Once again, they stress the decisive role of focusing on the core concepts and axioms that are present in any use of statistics. However, they also propose that statistical instruction be viewed as a continuum for each level of social work education: the BSW, the MSW, and the Ph.D. This should include a cumulative organization of statistical teaching, moving from the simplest procedures to the more sophisticated techniques. As well, instructors must emphasize the ability to read and understand statistical analyses, and to be able to compute one's own research. It is vital that statistics not be taught in a vacuum. Intrinsic in this model is the importance of teaching the applicability of statistics to social problem areas, including the where, when and why of statistical analyses. If this is to happen, Glisson & Fischer state, the traditional lecture/blackboard approach must be abandoned in favour of interactive methods of learning, new approaches to conceptualizing and understanding problems, the provision of concrete examples, and the inclusion of geometric and algebraic expressions as tools for statistical understanding. Lastly, the authors stipulate that computer literacy is an integral part of statistical training. They argue that the complexity of advanced statistics and the need to master computer applications mandates social work students to become knowledgeable in the use of modern technology.

We have identified a number of critical educational principles that social work educators suggest are intrinsic in any attempt to overcome problems of statistical training. These axioms include a focus on basic, core concepts of statistics, a critical problem solving approach to instruction, an emphasis on developing innovation and creativity, the integration of research and statistics into practice, the role of individuated, adult styles of learning, and the need to introduce computer technology as a component of statistical instruction. What alternative may best offer social work education the possibility of combining these principles? In the following section we will review the selection of such an alternative.

AN ALTERNATIVE MODE OF TEACHING

With the above educational principles in mind, social work must examine alternative methods of teaching that incorporate as many of these axioms as possible, in as effective a manner as possible. In a review of the literature a relatively new alternative is consistently cited as meeting the criteria set forth by the above educators. This alternative is the use of information technology as an aid for effective teaching. More specifically computer technology offers much promise for social work education.

The mandate to explore the utility of computers in social work education has been established. The most recent CSWE Curriculum Policy Statement outlines the development and assessment of new knowledge and programs utilizing information technology as a critical avenue for the renewal of social work education; (Hokenstad, 1984). Clearly computer skills and their utilization must be on the agenda of all social work curriculums (Glisson & Fischer, 1987; Hokenstad, 1984). Moreover, Brauns & Kramer (1987) call for the development of curriculum components that would enable social workers to utilize and influence the application of information technology. This includes developing skills for creative and responsible application of information technology through specialized education in technology applications.

Considering these mandates, and the inherent integration of statistics and computers, it is only natural to consider the utilization of computers as a tool to enhance statistical instruction. As mentioned previously, the current marriage of statistics with very limited exposure to computer course work poses difficulties for students and educators alike. Without a concurrent exposure to computers and the diversity of computer applications, training in such areas as statistics is only partially successful. Typically students experience unpleasant associations toward statistics in general, and when mated with computer technology a compounded, phobic-like reaction occurs. Together, these reactions ensure that both statistical competency and computer literacy suffer (Parker et al., 1987).

The literature, however, does suggest a use of computers that may allow for the simultaneous enhancement of both statistical competency and computer literacy goals. The educational process may, in fact, be enhanced by the vehicles of computer assisted learning (CAL) and computer assisted instruction (CAI) (LaMendola, 1987; Oliver & Huxley, 1988). It should be noted that these two terms are used interchangeably in the literature. The author, however, makes a distinction between CAI and CAL. For our purposes computer assisted instruction is defined as the utilization of computer technology - both hardware and software - in the conceptualization, design and implementation of the the instructional or teaching experience, as related to a particular substantive area. Computer assisted learning, however, refers to the actual process of learning, via computer based instruction, that the students themself experience. As this thesis focuses on the instruction of statistics within social work, the term CAI will be used for the remainder of the thesis.

Computer assisted instruction has been shown to address a number of the limitations that currently exist in contemporary statistical instruction techniques. For example, in a social work test of CAI for mental health instruction in the United Kingdom, it was concluded that CAI offered an interactive basis for learning, a chance for students to gain "hands-on" computer experience, a highly accepted basis for learning, and a cost-effective means of delivering instruction. Moreover, it allowed for a self-paced style of learning and opportunity for self-assessment (Oliver & Huxley, 1988). Other explorations of CAI have found that CAI may be highly interactive, allowing for individuated learning (Stonier, 1987). As well, it provides effective positive reinforcement, infinite patience, innovative and creative exploration of substantive areas, and the ability to simulate complex situations (Stonier, 1987). Finally computer assisted instruction may be utilized in problem solving endeavors, offers easily modified data manipulation, and is easily intelligible to the novice user (Price, 1987).

Clearly, then, computer assisted instruction may offer statistical training crucial capacities that can strengthen the learning process. It offers the capability for a critical problem solving approach to instruction, for innovation and creativity in the instructional process, for building practice scenarios into the research process, for structuring individuated, adult styles of learning, and for meeting the mandate of introducing computer technology to social work education. For these reasons computer assisted instruction appears to address the deficiencies found in traditional statistical education.

SUMMARY

In this section we have reviewed the literature in the area of research and statistical instruction within social work. It was found that contemporary social work education experiences much debate regarding both the relevance and nature of statistical training for social workers. The literature identifies a number of deficiencies in statistical instruction that result in social workers who are ill equipped to conduct empirically based practice. For this reason social work educators must explore ways to correct these deficiencies. Information technology, or more specifically, computer assisted instruction (CAI), has been shown to provide a means of incorporating educational principles that have already been identified by social work educators. The remainder of this thesis, therefore, will focus on the development of a prototype interactive tutorial system (ITS) that will demonstrate the benefits of computer assisted instruction as a vehicle for strengthening statistical instruction in social work education.

In order to embark on developing any computer assisted instructional software, however, one must form an understanding of a few key concepts surrounding computer assisted instruction (Soulier, 1988). In effect, a conceptual framework is needed, a framework that guides the evolution of any computer assisted intruction application, including the proposed ITS. The conceptual framework defines the terms of reference for exploring computer assisted instruction, sets the parameters that define the nature of the prototype, and creates the foundation that will underlie the actual structure of the prototype ITS.

The following section provides such a conceptual framework. It will further outline the concept of computer assisted instruction, and expand upon the power and utility provided by computer assisted instruction. As well, the emergence of two new, innovative tools for CAI (called *object oriented programming* and *hypertext*) will be discussed. Together these topics establish the underpinning that will pilot the actual structure of the development process for the prototype tutorial.

CHAPTER THREE

THE POWER AND UTILITY OF COMPUTER ASSISTED INSTRUCTION

In this chapter we review a few key concepts surrounding computer assisted instruction. In so doing we provide a conceptual framework that will guide the evolution of the proposed interactive tutoring system (ITS) for statistics. The conceptual framework defines the terms of reference for exploring computer assisted instruction, sets the parameters that define the nature of the prototype, and creates the foundation that will underlie the actual structure of the prototype software. We begin by considering the general field of computer assisted instruction.

THE NATURE OF COMPUTER ASSISTED INSTRUCTION

The reader should be aware that a number of terms are used in the literature in reference to the use of computers as a tool of instruction. These include computer based instruction (CBI), computer based training (CBT), computer based education (CBE), and computer managed instruction (CMI). The two most common terms found in the literature, however, are computer assisted instruction (CAI) and computer assisted learning (CAL). Both of these terms are used interchangeably in many situations. The author, however, makes a distinction between CAI and CAL. Following the lead of Lepper (1985), one can define CAI as the use of a computer as an instructional tool to enhance student motivation and the effectiveness and efficiency of instruction. I will further define CAI as the utilization of computer technology - both hardware and software - in the conceptualization, design and implementation of the instructional or teaching experience, as related to a particular substantive area. Computer assisted learning, however, refers to the actual process of learning, via computer based instruction, that the students themself experience.

Computer assisted instruction has been discussed in the literature for over two decades, but it is only with the recent popularity of the microcomputer that the value of CAI has become a prevalent topic for educators. With this trend has come a focus on the creation, selection and use of computer assisted instruction. As part of this process, varying classes of CAI have been identified in the literature.

Wilson (1985) identifies three sources for CAI in education. These include ready-made computer packages, template systems, and self-created CAI applications. Ready-made CAI applications offer immediate and reasonably priced educational software in exchange for little substantive input on the part of the educator. As a consequence, while quick and relatively easy to apply, such applications are the most limiting for the educator. Template systems are programs which allow educators to insert lessons into predetermined formats. Such formats, however, may lead to user boredom, and are again restrictive in terms of adaptability. Finally, self-created CAI applications are programmed by educators themselves, using an authoring language designed for that purpose. It is suggested that self-created CAI is the most satisfying of the CAI types, and offers much more utility in terms of content, structure, and levels of difficulty.

On a more specific level, CAI has generally been characterized into four typologies in the literature. These include: computer managed instruction, simulations, drill and practice and tutorials (Berven, 1985).

Bitter & Camuse (1984) state that computer managed instruction involves the use of computers to administer the instructional process, rather than providing instruction directly. Its value lies in individualizing instruction by maintaining unique objectives for each student, administering tests to evaluate attainment of objectives, diagnosing deficiencies, and assigning outside activities based on diagnosed learning needs (Berven, 1985).

Simulation CAI packages, on the other hand, attempt to approximate a working analogy of a problem-solving situation in real life. The computer is programmed to act like a person or system, and the student interacts with the system to explore alternative behaviours and strategies to determine their varying effects (Frenzel, 1980). In professional education the majority of computer simulations are clinical problem-solving simulations in which the computer is programmed to function as a client or clinical situation (Berven, 1985).

Drill and practice applications provide repetitions of facts or terminology until they are committed to the student's memory, or provide simple problems to practice until the required skills are mastered. Compared with traditional study methods, drill and practice CAI applications can provide a more interesting format for memorizing facts and mastering basic skills (Bitter & Camuse, 1984). Such applications are particularly valuable for enhancing the retention of the basic skills requisite to a particular core knowledge for any substantive area (Berven, 1985). Aligned closely with traditional programming techniques, drill and practice CAI represents approximately seventy percent of all commercially available CAI for the microcomputer (Jonassen, 1987).

Finally, tutorial forms of CAI are computer based, programmed instruction for teaching new information and concepts (Frenzel, 1980). Instructional material is divided into small units or frames that can be linked in a number of ways to form lessons and sequences of lessons. The linkages between frames of material can be either linear or branching (Bitter & Camuse, 1984). Linear tutorials are rigidly structured, with all students following the same sequence of frames and lessons. Branching tutorials, however, are individualized in that computer administered pre-tests and post-tests are used to guide students through unique sequences according to their own learning needs. Compared with other forms of CAI, tutorials can be much more complex to design and program, and generally require a powerful authoring system or programming language to design and write the application (Berven, 1985). It is the tutorial form of CAI that constitutes the basis for the proposed interactive tutoring system (ITS) in this thesis.

Regardless of the type of CAI application selected for use, a number of elements are common to all CAI formats. Kearsley (1983) states that there are four major elements of a CAI system. These include the computer hardware, the software that allows the system to operate, the courseware (the program used to present instructional lessons) and the humanware (all of the people with specialized expertise who contribute to developing a CAI system). Each of these is considered to be equally important in the success of any CAI program. If any one element fails, or is missing, the CAI program will inevitably fail.

Price (1987) goes further, and argues that once the hardware and expertise are in place, the most important elements to be considered in any CAI system are the:

1. System interface - the use of menus and commands to interact with the user;
2. Organization of lesson material - frames of textual or graphic information organized into linear or non-linear lessons;
3. Authoring systems/languages available - the selection and use of traditional programming languages (such as BASIC), or CAI authoring languages as the basis to develop CAI packages;
4. Suitability for storing records on student performance - record keeping for the purpose of providing feedback to students, progress monitoring, identifying weakness in teaching methods, enabling continuous assessment, and computerizing examinations; and
5. Message facilities offered by the system - the two way dialogue between student and teacher.

Winne (1989) expands on these concepts, and maintains that computer assisted instruction packages are beginning to develop artificial intelligence. With such capacities, new forms of CAI, which he terms intelligent tutoring systems, are designed to *interact* with a student in enhancing the learning process. To accomplish this a number of factors must be present:

1. The ITS contains representations of information that reflect instructional objectives not achieved by a student. That is, the ITS "knows" something a student does not.
2. The ITS was designed to compute (create) a particular path, as opposed to a random one or one completely determined by the student. This "artificial intention" on the part of the application is achieved through a large set of possible states of interaction with the student. The path ends at a representation of information considered to represent the educational objective.
3. The ITS creates or addresses intermediate representations of information that are connected to a representation(s) of each educational objective. In this manner a sense of coherence, discipline, and a model of instructional effectiveness are achieved. Such capacities embody the artificial "cognition" related to instruction.

Moreover, Winne (1989) argues that in order to make any ITS assume a sense of artificially intelligent behaviour the following conditions must be met:

1. Within a single interface, the ITS would adapt its behaviour to the student.
2. When adaptation reaches its limits, ITS would select for the student, or invite the student to select, an alternate interface for instruction. Alternative interfaces would be designed by ITS developers to provide alternative cognitive and behavioral means for approaching instructional goals.
3. When selection of alternative interfaces reaches its limit, ITS would seek to shape the student's cognitive strategies for learning from instruction. The objective of this behaviour would be to boost the student's capacity for interacting intelligently with the ITS.

Gagne, Wager & Rojas (1981) state that, when building such intelligence into a CAI application, a number of instructional events must be considered for any complete act of learning to occur. These "events of instruction" include (1) gaining attention; (2) informing learner of lesson objective; (3) stimulating recall of prior learning; (4) presenting stimuli with distinctive features; (5) guiding learning; (6) eliciting performance; (7) providing informative feedback; (8) assessing performance; and (9) enhancing retention and learning transfer.

Obviously, then, even with authoring languages designed to make the above processes easier, the development of CAI is not a minor task. The educator must create, via complex representations of information, that "artificial intention" which will guide students through the learning process. This requires a single interface for the student, but at the same time an interface that offers multiple paths leading to the same cognitive conclusion. Wilson (1985) suggests that developing such a system requires inclusion of a number of critical features. These include response time of the system, reliability and ability to record student performance. Of particular interest are capacities for sound and graphics capabilities, and the ability of the CAI application to incorporate branching.

Quite plainly, then, the development of CAI is not without disadvantages. It has been argued that the development of CAI will consume much more time than planning conventional instruction (Wilson, 1985). Wilson also suggests that CAI programs may not be portable from one computer system to another, quality control standards of CAI are virtually non-existent, and programs that are purchased may lack adequate documentation. Moreover, available programs may not devote an appropriate amount of time to the concepts of interest, and may not be flexible enough to allow students to move from once concept to another easily.

Flynn (1990) argues that the major disadvantage of CAI lies in the fact that "the instructor must spend a great deal of personal resources in clearly explicating learning objectives and in using the authoring language and computer loading procedures in order to make the lesson available. The tasks of creation and editing are very time-consuming. Kearsley (1983) concurs, and suggests that current limitations of CAI lie in issues of reliability, ease and simplicity of use, hardware availability, courseware compatibility, and especially in finding the combination of instructional design and programming skills in educators.

On the other hand, Flynn (1990) also suggests that there are a number of advantages to the use of CAI. When time is available, new lessons can be made on new and relevant topics and the opportunities for learning through this medium continue to expand. Moreover, CAI allows the learner to move at their own pace, the computer is an objective medium for instruction, computers can be available at the students' convenience, and computers offer immediate and rapid access to vast amounts of instructional material. As well, the process of specifying the objectives and content of a learning episode forces the instructor to be precise in the design of instructional material. In short, CAI applications offer important contributions as supplemental approaches to instruction in social work.

Reinoehl (1990) contends that ITS offers learners more control to direct the unfolding of the learning interaction, hence the shape of the learning. As well, these systems can also provide diagnostic feedback. In a very real sense the learner is perceived as "an active agent whose cognitive structures are undergoing change as he interacts with a learning system". This rationale pervades emerging forms of CAI. Learning is seen as an individual, constructive activity, so learning activities need to allow for individual encoding of instructional materials rather than controlling the encoding process for the learner. This capacity for individualized, interactive communication between the learner and the computer is the primary benefit of CAI (Jonassen, 1987).

THE VALUE OF CAI

Considering both the deficiencies and merits of CAI, what conclusions can then be drawn about the value of CAI for social work education? Poulin & Walter (1990) conclude that examples of CAI are relatively rare in social work education, especially at the undergraduate level. Still, it has been noted that the educational process may, in fact, be enhanced by the vehicles of computer assisted learning (CAL) and computer assisted instruction (CAI) (LaMendola, 1987; Oliver & Huxley, 1988). For particular learning applications, computers can make instruction more effective or efficient than traditional methods of instruction (Flynn, 1990; Kearsley, Hunter & Siedel, 1983; Wilson, 1985). Finally, Reinoehl (1990) adds that the "positive effect of self-efficacy on learners is well documented", and that such technology will enable educators to explore the boundaries of knowledge in ways never before possible. In summary, as Wilson (1985) states, the educational opportunities offered by CAI "justify the cost in time and money of producing high quality computer assisted instruction".

With the terms of reference for computer assisted instruction defined, what parameters will determine the nature of the prototype ITS? Again, it is to be a CAI application created using an interactive, tutorial format. This implies that the instructional material will be divided into small units or frames, linked in a branching manner, to form lessons and sequences of lessons. As well, the tutorial is to be utilize a standard interface, yet one that is interactive and allows for individualization of learning. Alternate paths of learning must be available to the learner. Traditionally, such an application would be exceedingly difficult to create using procedural programming languages. Two relatively new innovations in programming tools, however, do promise to make such elements much easier to create. These innovations are object oriented programming, and hypertext. We begin with a discussion of object oriented programming.

OBJECT ORIENTED PROGRAMMING

Traditional software programming utilizes a linear form of logic, a logic that can make no assumptions about how we can communicate with the computer. In other words, each element of any application must be programmed and manipulated as a unique, individual entity. As a result, the behaviour of software is rigidly structured, and must be manually handled by its programmer across a whole range of possible circumstances. With the increasing complexity of computer software this means that applications are becoming more and more difficult to program and manage (Dataflex UIMS Handbook, 1990).

Recently, however, object oriented programming (OOP) has promised an innovative means of coping with this complexity. Object oriented programming (OOP) represents a logical progression from traditional, linear programming. It offers a non-linear method of programming and manipulating each element of any application, meaning that programming code may be localized, reused and shared. The result is a more efficient, perhaps more effective method of software development.

In our everyday lives objects can be anything: a book, keys, sand, birds, flowers. We often group objects which share properties, or behave in a common manner. For example, we can group the modern automobile into an entity called a car. We would all agree that cars in general share properties, such as the presence of wheels and motors, or the ability to seat people. Likewise, cars behave in a common way. They are all able to move, stop, and turn. Such assumptions regarding cars allow us to ignore many of the details that distinguish one automobile from another. More importantly, they allow us to design and operate different cars without undue complexity and effort. In effect, because the properties of a car are generic, we may reuse and share design and operation principles.

Such is the concept behind object oriented programming. In an object oriented computer environment, objects can include numbers, files, pictures, lists, even windows (screen images). All of these objects act or are manipulated according to the same principles. Each is a self-contained unit of both functionality and data (Actor User's Manual, 1990). For example, a "list" object meant to maintain a directory of addresses contains data - the names and addresses of individuals. At the same time, the list object is accountable for all operations that can be performed on that directory of names and addresses. These operations could involve displaying the list, changing the list, sorting the list in a number of ways, or printing portions of the list. Conceptually, this means that objects "know" how to do something or understand a message sent to them by other objects. This concept is a major shift away from traditional programming, where data and the procedures to perform operations on that data are physically and logically distinct from one another (Shafer, 1989).

Each of an object's functions is accomplished by means of a "message" that is sent to that particular object. A message is simply a signal to an object to return some information about itself, or to carry out an action. In fact, everything in an object oriented environment happens by one object sending another a message (Shafer, 1989). For example, the programmer may write a sequence of code that will allow the user to "click" on an image of an address book. When that happens a message is sent to the address list to display itself on the computer screen. Then, when ready to sort the list, the user may "click" on an option to sort the list. When that occurs, a message is sent to the list object to sort itself on a predefined basis, and the action occurs. All object behaviours, then, are controlled by a message of some type.

All operations for a single object can be localized to that object alone, making programming easier. However, these operations and messages can be generalized to any number of similar objects. When we group similar objects together, these groupings are called a class. A class is simply a particular kind of object that shares common attributes, or a template that defines similar objects. In the case of computers, the concept "list" would be considered a class. Each particular object is then known as an instance of that class. We could have a number of instances of the "list" class; lists of addresses, author names, inventories, and so on.

The advantages to the use of objects, classes, instances, and messages are twofold. The first revolves around the ability to connect information in an interrelated, associative fashion. Whereas traditional procedural programming relies on hierarchies of procedures and global knowledge of data and structure, object oriented programming relies only upon the local knowledge of objects. It is the interconnections between these objects that define the structure of any application. In other words, object oriented programming functions much like the human mind. Links can be made between bodies of information in a "natural" way, through associations of objects (Plus User's Manual, 1990). Information management thus becomes more intuitive and flexible, and simplifies the development of an application. In effect, more sophisticated and powerful computer applications may be developed by individuals who are not expert procedural programmers.

Secondly, because each object in an OOP application is a discrete entity, the code that created and maintains the object is discrete. This tends to isolate specific functions of an application, so that they may be altered without drastic revisions of the software as a whole. Yet, at the same time, this code will likely work with many other similar objects; other instances of the same class. For example, a command to "draw" a chart will work with bar charts, pie charts, and line graphs. The result is that the programmer may easily select distinct portions of an application (e.g. particular objects), and reuse them in other software. Just as importantly, not only may code be reused, but conceptualization and design of software may be transferable. The programmer will eventually develop a "library" of classes, objects, and functions which may be manipulated to create a variety of software applications, regardless of the substantive area.

These two capacities - the simplification of programming, and the ability to reuse the conceptualization, design and code of software across substantive areas - promise to be a great tool for educators interested in the development of CAI. Especially exciting, though, is the capacity that OOP offers for the interconnection of objects in any number of fashions. Because links between objects can be made in an intuitive manner, both flexibility and an interactive environment may be built into any application. Object oriented programming offers exactly what is required for the prototype ITS: the ability to divide instructional material into small units or frames, organized in a branching manner, to form lessons and sequences of lessons. These linkages, or branches, however, are best understood in terms of the other innovation in programming tools. This innovation, often included in object oriented programming languages, is the concept of hypertext.

THE CONCEPT OF HYPERTEXT

Our normal perception of text, whether in print or electronic form, is one that sees information arranged in a sequential, linear format. All individuals who examine this text, such as the writing in a book, follow the same front to back path through this information.

This results in a standard means of exploring the same information, even though the reader may have very different preferences or learning styles. Such is also the case for most computer assisted instruction. (Jonassen, 1986).

The concept of hypertext, however, focuses on non-linearity. First developed by computer pioneer Ted Nelson in the 1960's, hypertext is a term that describes masses of information that can be accessed nonsequentially (Quraishi, 1990). The result is a totally nonlinear collection of pieces of information of any size that all relate to a single topic or idea. In other words, all users need not follow the standard, front to back means of exploring the same information. Hypertext creates multiple pathways (structures, branches, or alternatives) by which the user can explore individualized paths or lines of inquiry through any application. Depending on what the user is interested in investigating, he or she will be offered a unique presentation of the material at hand (Megarry, 1988).

Nelson (1978) identified three levels of hypertext. The simplest and original concept of hypertext is called node-link or chunk hypertext. Node-link hypertext functions on a random access model, whereby the user has immediate access to any chunk of information within a collection of material (Jonassen, 1986). In essence it is an unstructured way of relating or linking material. Nelson himself, however, quickly realized that a total lack of hypertext structure could lead to meaningless associations between concepts (Nelson, 1978). Therefore, he developed a second level of hypertext called structured hypertext. Structured hypertext consists of collections of nodes or modules of information. Each module of text is distinct and separate, but accessible from any other module. The third level of hypertext is called hierarchical hypertext. It is the most structured of hypertext designs, and involves arranging all nodes of text in a hierarchical fashion. Substantive content is arrayed so that general concepts are broken down into more detailed concepts. The user may access any general concept, and then select to focus more closely on detailed content subsumed underneath, or move to any other general concept. At any point the user may move deeper into the hierarchy, or choose to move back to a more general exploration of the material. It is suggested that this hierarchical structure is the most common representation and use of hypertext (Jonassen, 1978).

All of these frameworks for comprehending information are based on a conceptual basis of generative learning (Wittrock, 1978). Principles of generative learning suggest that individuals interpret informational stimuli through the activation of prior knowledge structures. This means that we are able to make sense of new information only sofar as our own prior knowledge provides a context to explain it. By this generative model, then, learning is an active process of constructing knowledge, and given the same information, each of us will generate somewhat different interpretations for it (Jonassen, 1986). Hypertext gives learners the ability to individualize the knowledge aquistions process, and learn according to their own preferred sequences by allowing them to choose their own path through any collection of information (Jonassen, 1986, Nelson, 1978).

Computers lend themself to implementing hypertext especially well for four reasons (Nelson, 1978). Their high resolution screens can present text and graphics in various sizes and formats simultaneously, and almost immediately switch to another screen of information. Secondly, computers have developed sufficient speed to maintain instant access to a wide array of information, responding quickly to the user's request or command. Thirdly, computers allow programmers to build easily accessible links between pieces of information stored in separate locations on the machine. Lastly, these links enable the user to "window" between one topic or collection of information to another. Together, these capabilities provide the ideal vehicle for hypertext based material.

In combination the concept of hypertext, which allows for multiple and non-sequential paths through information, and the ability of computers to facilitate this process, would appear to be a powerful tool for CAI. Yet, because examples of CAI are relatively rare in social work education (Poulin & Walter, 1990), hypertext has never been fully explored as a vehicle to enhance learning in social work education. Therefore, hypertext will be considered an integral component of the proposed ITS for statistics.

SUMMARY

In this chapter we have provided a conceptual framework that will guide the evolution of the proposed interactive tutoring system (ITS) for statistics. The conceptual framework is based on valuable principles that we have identified for CAI, object oriented programming, and hypertext. Together, these terms of reference define the structure of the ITS.

Using these terms of reference, the prototype ITS for statistics will be structured using the following specifications:

1. A CAI application for teaching concepts and information regarding statistics, using a tutorial format;
2. Lessons will be arranged in a branching manner, with instructional material divided into units or frames;
3. The ITS will include a standard, interactive interface, yet allow for alternate paths of learning toward the same educational objectives;

4. The ITS will be created using an object oriented environment, in order to facilitate ease of program design, implementation, and maintenance; and

5. The ITS will include hypertext capabilities, in order to facilitate individualized lines of inquiry and learning for the student.

Even though these specifications give a broad understanding of the nature of the prototype ITS, the exact structure and content of the ITS have yet to be defined.
The following chapter provides this framework. It will further outline the structure and content of the ITS for statistics. As well, the prototyping process must be defined. This includes the purpose of the application, the selection of a substantive basis for the ITS, the selection of an object oriented application development software, and the design procedures utilized in the development of the prototype. Together these topics will detail the development of the prototype ITS.

CHAPTER FOUR

THE PROTOTYPING PROCESS

In this chapter we review the methods and procedures significant to the development of the prototype interactive tutoring system (ITS) for statistics. In so doing we detail the prototyping process, including the purpose of the prototype, prototype specifications, the selection of a substantive basis for the ITS, the selection of an application development software, the design model, and procedures utilized in the development of the prototype. We begin by considering the general purpose of the prototype ITS for statistics.

PURPOSE OF THE PROTOTYPE ITS

Kearsley (1986) defines a prototype as "a working model or mockup of the actual program". As such it is not intended to produce a full, working version of a software application. Rather, a prototype is only a small representation of the entire program and usually contains a few representative displays or sequences. The challenge, Kearsley suggests, is to create enough of the program to illustrate how it will work. This process involves generating the basic design of the application and its screens, programming its critical sequences, and estimating how long the full application might take to develop. By working through these procedures the software developer is able to move from a static, flat visualization of a software program to a functional model that conveys interactive and dynamic aspects. In effect, we can gain a precise understanding of exactly how a program may work through the development of a prototype.

Such is the intent of the prototype ITS for statistics. This prototype, to be called **HyperStat** in recognition of its hypertext capacities, does not constitute a complete, working version of an ITS for statistics. To do so is quite simply beyond the scope of the current study. Rather, it is a precise, working model of the program. Its intent is to provide a visualization of how the program might work, and to assess the benefits and limitations of this type of software for social work education. Thus, while **HyperStat** utilizes an interactive, dynamic interface, it will only be a representation of a much larger possible software application.

SPECIFICATIONS FOR THE PROTOTYPE ITS

In the previous chapter we developed a conceptual framework that guides the evolution of the proposed interactive tutoring system (ITS) for statistics. This conceptual framework defines the structure of **HyperStat** as follows:

1. A CAI application for teaching concepts and information regarding statistics, using a tutorial format;
2. Lessons will be arranged in a branching manner, with instructional material divided into units or frames;
3. The ITS will include a standard, interactive interface, yet allow for alternate paths of learning toward the same educational objectives;
4. The ITS will be created using an object oriented environment, in order to facilitate ease of program design, implementation, and maintenance; and
5. The ITS will include hypertext capabilities, in order to facilitate individualized lines of inquiry and learning for the student.

SUBSTANTIVE CONTENT FOR THE PROTOTYPE ITS

The development of a prototype ITS for statistics involves some critical decisions regarding the substantive content to be included in the software. As the area of statistics encompasses a broad range of concepts and procedures, specific content had to be chosen for the prototype.

It was decided that the precise content to form the foundation of **HyperStat** should be that of introductory statistics for undergraduate social work students. Again, this decision was based on a series of factors:

- the author's familiarity with the substantive area, through teaching of introductory statistics to undergraduate and graduate social work students;
- the author's familiarity with the common difficulties and issues faced by social work students attempting to learn introductory statistics; and
- the evidence that suggests social work educators and students currently encounter difficulty in exploring introductory statistics.

Once the substantive area had been chosen, a more specific choice was faced. This choice involved selection of the exact material to be incorporated into **HyperStat**. It was felt that a structured content base would be most useful for the development of the prototype ITS. Such a structure can be found in a high quality statistics text. Toward this end, permission was gained to base **HyperStat** on the text *Statistics for Social Workers* (Weinbach & Grinnell, 1991). Once again this decision was precipitated by the author's familiarity with the text, and its widespread use in the social work community. Finally, for the purposes of the prototype, the selection of the first two chapters of the text - basic statistical concepts and the use of tables - were selected as the content basis for **HyperStat**.

SELECTION OF AN APPLICATION DEVELOPMENT PLATFORM

The selection of an application development platform - the hardware and programming software to be utilized - is critical for any successful software development. With this in mind, the author conducted a rather lengthy exploration of varying hardware and software options that would be suitable for the purposes of the thesis. This search was conducted with a specific set of criteria and rationales. These criteria are as follows.

- The hardware platform chosen for **HyperStat** development was that of IBM compatible personal computers. This selection is based on a number of factors. These personal computers have a distinct advantage over other computer systems in terms of an established user base. This makes any software application more readily available to a broader population, and therefore hopefully more functional. Moreover, for most social work agencies and educational institutions cost is always a factor. Other hardware platforms are typically more expensive, and therefore generally less readily available to social workers. Finally, recent advances in application development software for IBM compatible computer systems have offered the promise of delivering more interactive and flexible options to programmers. This promise alone makes further exploration of the compatible personal computers a timely endeavour.
- The application development software had to utilize an object oriented programming environment, in order to facilitate ease of program design, implementation, and maintenance.
- The application development software had to include hypertext capabilities, in order to facilitate individualized lines of inquiry and learning for the student.

- The application development software had to possess a fully evolved scripting language. This was necessary in order to accommodate the complexity of creating multiple paths of inquiry in **HyperStat**, the design of an interactive interface, and the inclusion of numerous graphics, a help system, scored questions, and so on. At the same time, however, the scripting language had to be one that did not require an advanced knowledge of software programming. The author, himself, was a neophyte software programmer, and did not possess advanced programming skills. Moreover, the intent was to discover a software tool that other educators might utilize without undue effort or burdens.
- The application development software had to include extensive graphics capabilities. This incorporated not only the capacity to display existing graphic images, but also the design and creation of images relevant to the substantive area - introductory statistics.

With the establishment of the above criteria, a prolonged, at times frustrating search began to find a suitable software development application. This search involved reviews found in popular computer journals and magazines, reviews of various demonstration copies of recent software development tools, and the purchase and testing of particularly promising software programs. Finally, in the summer of 1990, a new object oriented, hypertext capable development software was introduced to the personal computer market. This software was called Plus 2.0 from Spinnaker Software of Minneapolis, Minnesota (Plus, 1990). The software was purchased and tested, and was found to be quite suitable for development purposes. It therefore became the software foundation of **HyperStat**.

THE PROTOTYPING PROCESS

Alessi & Trollip (1985) suggest a model that is oriented directly toward computer delivery of instruction, including not only designing a lesson on paper, but also getting it into a computer and evaluating it. Briefly, the foundation of the model lies in the *design* of the lesson, starting with rough ideas, then engaging in the creative, flexible generation of ideas, followed by organizing and analyzing ideas. The model then turns to the *production* of the lesson, starting with the generation of text, graphic, and other presentations on paper, and finally progressing to the computer component, the detailed design, production, and evaluation of the computer program. It is suggested that the use of such a model is applicable to a wide range of substantive areas, and will prove valuable in the generation of creative and innovative computer-based instruction. The design and production of **HyperStat**, therefore, closely follows this model. The following are the eight steps of Alessi & Trollip's model and a brief synopsis of how the development of **HyperStat** reflects this model.

Step 1: Defining the Purpose

When setting out to design and develop instruction, one generally knows its general purpose, such as teaching "statistics". In this first step of program development the designer should determine the purpose or goal of a single lesson, which will generally include what the student should know and be able to do after using the lesson. The two main considerations in this process are precisely defining the preinstructional level of the student's knowledge and the hierarchical nature of the content that is to be taught.

In the case of **HyperStat** this step proved to be relatively uncomplicated. The preinstructional level of knowledge that social work students typically maintain regarding introductory statistics has been established elsewhere in the thesis. This level of knowledge can best be described as rudimentary. Therefore, the purpose of the content included in **HyperStat** is to introduce material *basic* to social work students understanding of statistics. The goals of individual lessons are in turn provided by the structure of *Statistics for Social Workers*. Two **HyperStat** lessons or modules were decided upon - the introduction of basic concepts necessary to begin learning statistics, and the explanation of commonly used data distribution tables in statistics. Each of these reflect beginning chapters in the chosen text.

Step 2: Collecting Resource Materials

Collecting resource materials includes gathering materials dealing with the subject matter, with instructional development, and with the instructional delivery system, in this case the computer. Regarding the subject matter, it never makes sense to "reinvent the wheel". The designer should find out what others have done that is related to what they intend to do. Useful subject matter resource materials generally include textbooks (for instance, the use of *Statistics for Social Workers* when planning to teach about statistics), reference books, original source materials, films, and other individuals knowledgeable in the particular area. Resource materials for instructional development include texts on instructional design, storyboarding sheets, graphics arts materials, a typewriter, and people who have done instructional design. Resource materials relevant to the delivery system include the computer itself, manuals on operating the computer, programming reference guides, and others experienced with the computer and programming language you intent to use. In all cases, the most important resource are other knowledgeable people.

Once again, the selection of a base text proved to be a great aid in the development of **HyperStat**, as context for the subject matter was readily available. Moreover, a search for similar development projects in social work produced negative results. This combination meant that the current study would not, in fact, reinvent the wheel, but would be exploring a new area in social work. Such a situation left the author with a great degree of freedom for creativity and flexibility in program design.

In terms of instructional development, the author utilized two sources for direction. Firstly, past experience with reviewing a wide variety of computer applications, in a professional capacity, proved useful in the development of **HyperStat**. This experience left the author with distinct preferences and dislikes for the interface design and presentation of materials in computer applications. Secondly, the author sought out and studied a number of sources related to the design and production of computer assisted instruction. Naturally, these also proved beneficial.

Resource materials relevant to the delivery system incorporated into **HyperStat** came from a number of sources. Relative familiarity with personal computer systems gave the author a solid foundation to begin the prototyping process. Additionally, reviews found in popular computer journals and magazines, reviews of various demonstration copies of recent software development tools, and the purchase and testing of particularly promising software programs gave the author a strong sense of the strengths and weaknesses of available development software. Finally, consulting the software manual of Plus, Version 2.0 (Plus, 1990), and learning its scripting language completed this step. It should be noted that this preparatory portion of the process, while not directly included in a consideration of development time for **HyperStat**, occurred over a period of approximately six months.

Step 3: Generating Ideas for the Lesson

For this step Alessi & Trollip suggest procedures for encouraging creative ideas in the development process. Many designers get stuck at this early point, either spending too much time trying to come up with the perfect idea, or, more frequently, giving up and going forward with a mediocre idea. They suggest using the procedure known as *brainstorming*, in which the designer, with assistance from others, pursues the goal of generating as many ideas as possible, suspending and judgment of the quality of feasibility of ideas until a later time. Brainstorming is suggested because it has proved to be a method that facilitates creativity and produces a list that will include some interesting and good ideas.

This third step proved to be perhaps the most interesting and invigorating of the development process. The author, the thesis supervisor, and a fellow graduate student held a prolonged meeting in which they *brainstormed* as many ideas as possible regarding the nature and development of **HyperStat**. In fact, substantial portions of the next three steps - organizing ideas, producing lesson displays on paper, and flowcharting the lesson were begun during this meeting. Topics covered at this session included a further definition of content to be included, instructional strategies to be utilized, program flow and navigation, display designs, the use of graphics, testing strategies, and programming techniques. In all instances the ideas were recorded on paper by the author, for further use later in the development process.

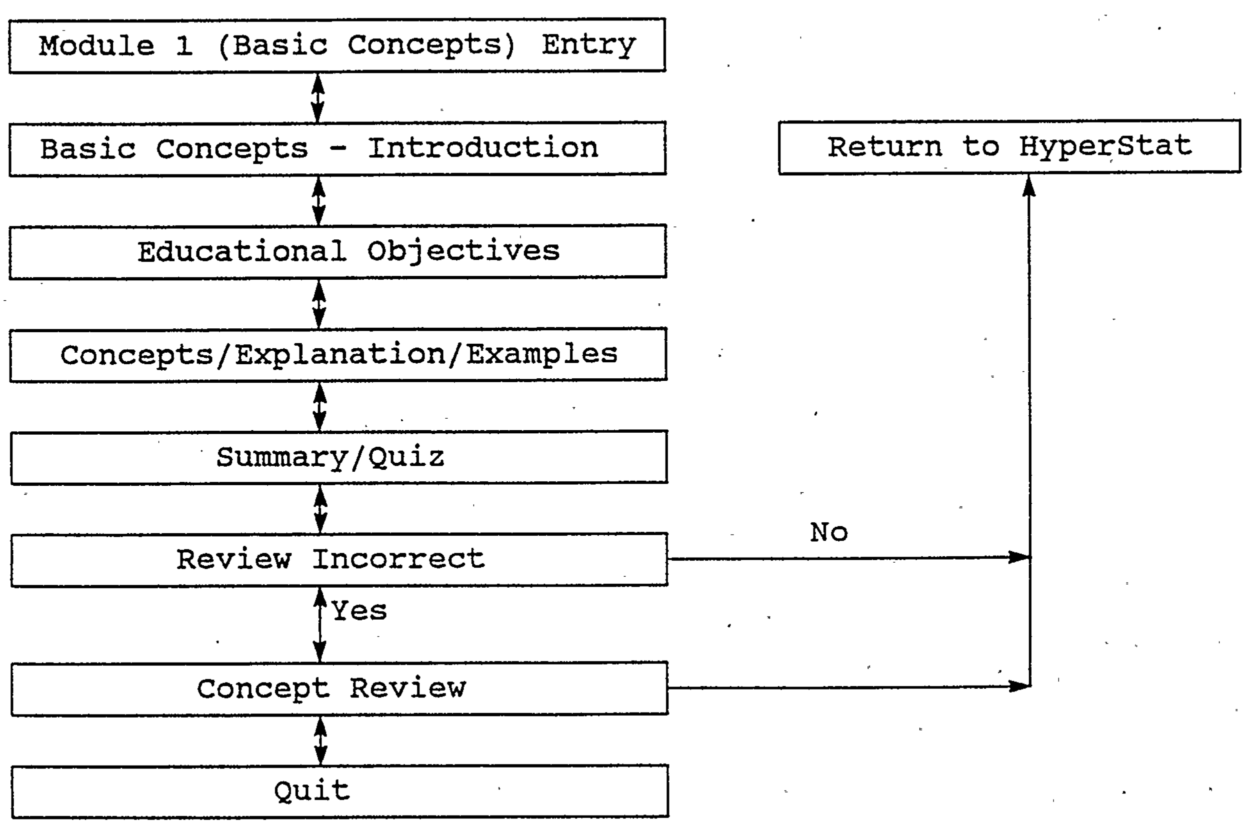
Step 4: Organizing Ideas for the Lesson

The outcome of brainstorming is a long list of ideas that range in quality from very bad to very good. In this step you first eliminate the worst ideas and then begin ordering, detailing, and refining the ideas that are good. At this time you also make preliminary choices about instructional methodologies and factors.

This step included the selection of ideas recorded in step 3. The author selected strategies and designs for inclusion in **HyperStat**, and began to further refine them on paper. This primarily involved refinements in terms of the order and detail of lesson content. Further amendments were also generated for program flow and screen design.

For example, Figure 4.1 below shows a sample of the preliminary design for the program flow of one lesson module.

Figure 4.1
Preliminary Program Flow of **HyperStat** Module 1:
Basic Statistical Concepts



Step 5: Producing Lesson Displays on Paper

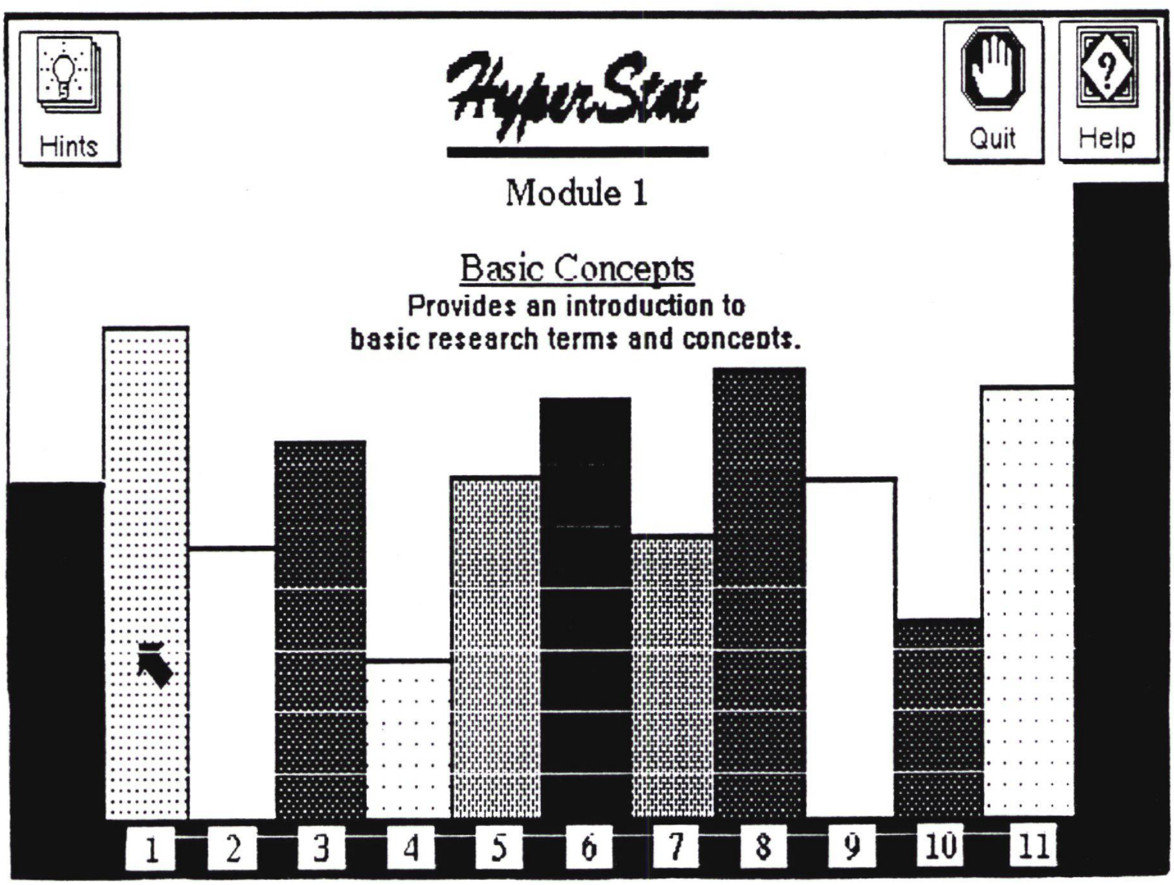
This is a critical stage, in that you move from design of a lesson to production of a lesson. It includes drafting the actual instructional messages as students will see them, such as information presentations, questions, feedback, directions and prompts. This step also includes preparing drafts of graphic presentations such as pictures, cartoons, graphs, and animations. Most importantly, it includes *storyboarding*, which is the process of rewriting textual and pictorial displays so they will fit within the display limitations of the computer.

Initial perceptions regarding the layout and operation of screen displays were generated in step 3 of program development. In this phase the author cultivated these ideas further. Basic screen layout was finalized for each portion of **HyperStat** and recorded on paper. The text to be included in lesson displays was derived from *Statistics for Social Workers*, and arranged to optimally fit into a computer presentation format. Especially important features, consisting of help screens and messages, navigation indicators, and hints to program operation were conceptualized and journaled. It should be noted that many of the graphic presentations - the images and graphs of **HyperStat** - were not developed at this point, as suggested by Alessi & Trollip. This was due to the author's relative unfamiliarity with the possibilities presented by the development software. Therefore, a number of the graphics were conceptualized and generated during the programming phase.

Examples of screen layout for **HyperStat** are shown on the following pages. While it is impossible to depict the interactive and dynamic nature of **HyperStat** through these images, it is hoped that these few images will impart a sense of the structure and design elements utilized in **HyperStat**.

It should be noted that only a small portion of the total screens, or cards, are shown on these pages. In total, **HyperStat** includes 85 of these cards. Each consists of multiple and often hidden components - text, graphics, messages, procedures. It is estimated that each of these screens and its requisite components required a total of 3-4 hours to conceptualize and program.

Figure 4.2
A Representation of **HyperStat**
Program Concepualization, Screen Design, and Instructional Context



Help

HyperStat

Module 1

Basic Concepts

This module provides an introduction to basic research terms and concepts.

Click here to return to list of modules.

To continue, click on this arrow.

Hints

Quick tips,Jackie

For examples, move the mouse over the objectives.

Click on the arrow to begin, or click on an objective to go to a specific topic.

On future screens, clicking on the black "speed" arrow at the bottom the screen will return you to these objectives.

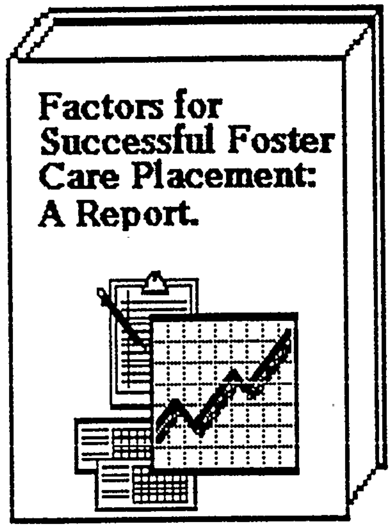
Help

Educational objectives for this module:

1. To foster appreciation for the value of statistics to practice decision making.
2. To introduce research terms and concepts necessary for understanding statistics.
3. To describe how the quality of measurement can affect the utility of statistics.
4. To provide an awareness of the different functions that statistics can perform for the researcher.

Hints

Help



Knowledge of statistics, therefore, is critical for:

Practice Decision Making

Evaluating Our Practice

Communicating Our Research Findings to Other Social Workers

Effective Review of Social Work Literature

Hints

Help

Hypotheses and Variables

A hypothesis is a simple statement written in such a way that it can be supported or not supported by comparison with known facts.

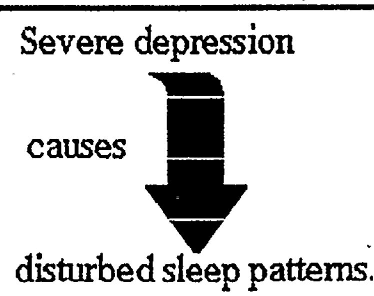
Hypothesis:
Disturbed sleep patterns cause severe depression.

For example, the above hypothesis predicts one kind of relationship between sleep patterns and depression.

Two ideas, sleep patterns and depression are our variables.

Much thought must go into your hypotheses. They are not static.

For example, our original hypothesis may also have said:



Hints

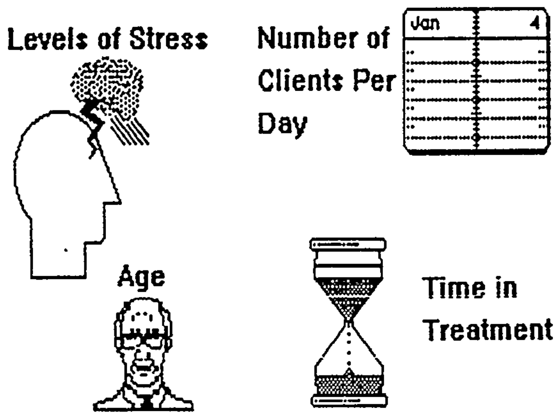
Help

Data and Variables

Many of our practice activities involve collecting and organizing information. This information is called data. Data are the starting points for scientific conclusions, and therefore must be highly accurate.

A variable is anything that can assume more than one form, state or type; it must vary in a population, and it must be measurable.

The variations for a variable are called values.



Hints

Help

Concept:
Self-Esteem (Dependent Variable)
Operationalization:
Scores on Standardized Esteem Scale

Operationalization

The process of selecting and specifying the specific measuring devices that will be used to measure the variables that have been conceptualized is called operationalization.

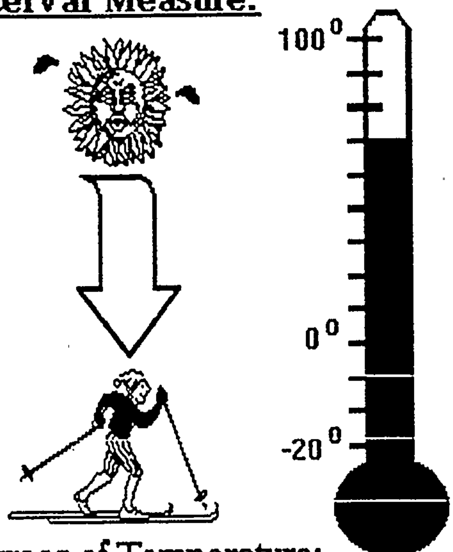
Operationalization attaches meaning to our variables by reducing them to measurable dimensions.

For example, an operationalization of the variable self-esteem may include observations of client behaviors or client responses on a standardized self-esteem scale.

Hints

Help

Interval Measure:



Degrees of Temperature:
Celcius or Fahrenheit

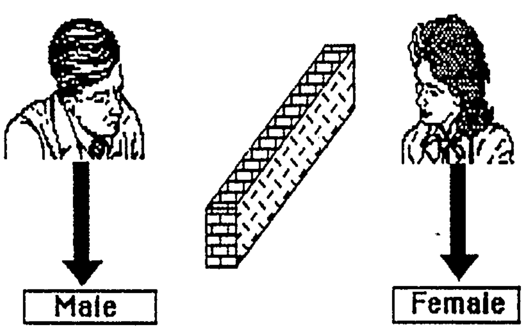
At some point, we must determine how precisely we are able to measure the variables we are studying. Choosing a level of measurement for our variables provides direction as to the type of statistical analysis that can be undertaken.

There are four levels of measurement:

Nominal
↓
Ordinal
↓
Interval
↓
Ratio

Hints

Help



The categories of "male" and "female" for the variable gender are:

Distinct: They are unique & separate.

Mutually Exclusive: You must be male or female.

Exhaustive: All people fit into a category - male or female.

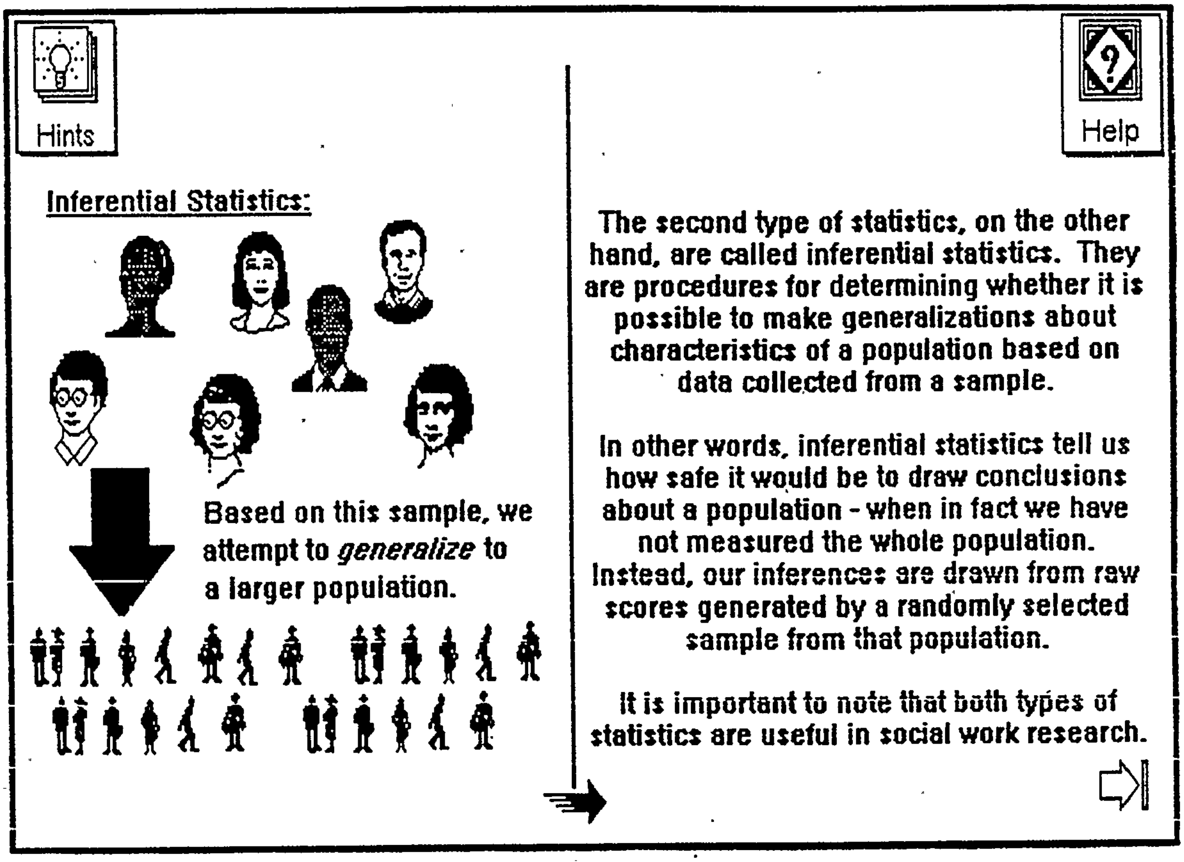
The requirements of nominal level measurement are minimal. It requires two or more categories which are :

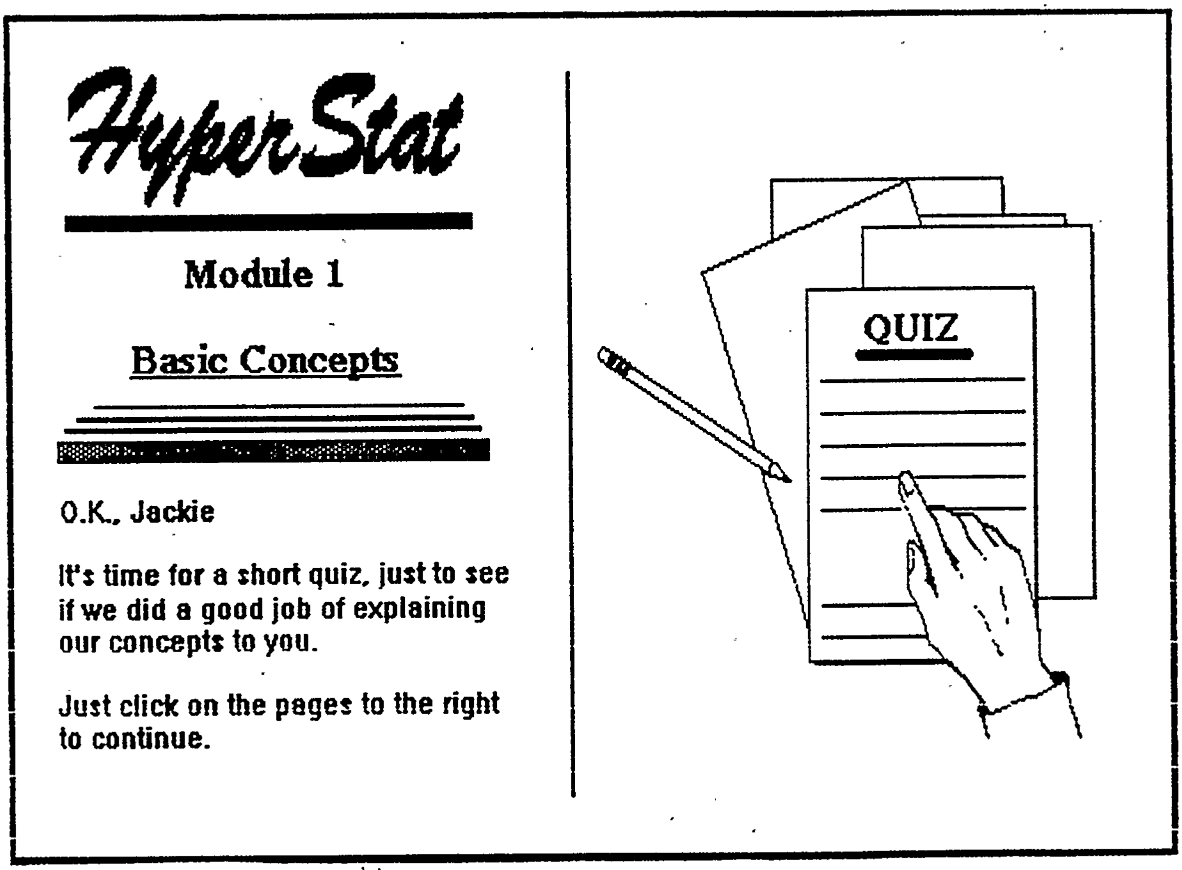
Distinct

Mutually Exclusive

Exhaustive

That is, each case must fit into only one category, and there must be an appropriate catetory for each case.


Hints
Help
Inferential Statistics:
Based on this sample, we attempt to *generalize* to a larger population.
The second type of statistics, on the other hand, are called inferential statistics. They are procedures for determining whether it is possible to make generalizations about characteristics of a population based on data collected from a sample.
In other words, inferential statistics tell us how safe it would be to draw conclusions about a population - when in fact we have not measured the whole population. Instead, our inferences are drawn from raw scores generated by a randomly selected sample from that population.
It is important to note that both types of statistics are useful in social work research.


HyperStat
Module 1
Basic Concepts
O.K., Jackie
It's time for a short quiz, just to see if we did a good job of explaining our concepts to you.
Just click on the pages to the right to continue.
QUIZ

HyperStat

Module 1

Basic Concepts

Please read each question carefully.

Click on the box beside the answer you choose.

If you wish to change your answer, simply click on your new choice.

Click on the arrow when finished.

Question One:

When a hypothesis is used in research, the researcher is seeking to explain:

- ☐ the variations that exist within measurements of the dependent variable.
- ☐ why the independent variable varies more than the dependent variable.
- ☐ the variations that exist within measurements of the independent variable.
- ☐ why the independent variable varies less than the dependent variable.

HyperStat

Module 1

Basic Concepts

You have now finished the first module.

We hope that it has helped to give you a better understanding of concepts basic to statistics, and has been enjoyable for you.

Let's see, Jackie

You scored 1 of a possible 5 points.

Click on the arrow below to review material related to the quiz you just completed.

Click on the bar graph to to return to the list of modules.

Click on quit to leave HyperStat.

Review Material | Modules | Quit

HyperStat

Module 1

Basic Concepts

For more specific review, click on the item of interest.

When reviewing information, click on the black speed arrow at the bottom of the screen to return here.

Readings Modules Quit

The following are the results of your quiz:

1. Review: A hypothesis seeks to explain the a). variations that exist within the measurements of the dependent variable.

2. Correct - Operationalizing a variable selects an instrument to be used to measure the variable.

3. Review: Measurement using values such as "always", "sometimes", and "never" are ________ data.
   b). ordinal data.

4. Review: "How many times have you been married will produce ________ data.
   d). ratio

5. Correct - statistics serve a multitude of uses - such as making practice decisions, designing research studies, and describing data.

Hints

Help

Cumulative Frequency Distributions

The second type of frequency distribution is the cumulative frequency distribution.

If our data is at least ordinal level, we can extend a basic absolute frequency table to form a cumulative frequency distribution.

Table 2.4 differs from an absolute frequency table only in that the far right hand column represents the cumulative frequencies of the clients' ages from low (21) to high (69).

Table 2.4
Cumulative Frequency Distribution Table: Clients' Names and Ages

	Ages	Absolute Frequency	Cumulative Frequency
Chuck, Tony	21	2	2
Brad, Herb, Karen	26	3	5
Mary, Peter, Robert	27	3	8
Kathy, Don, Leslie, and John	31	4	12
Janice, Bill	32	2	14
Richard, Lynne, Sue	37	3	17
Pat, Becky	49	2	19
David	69	1	20

Hints

Help

Using Tables for Comparisons

Cumulative frequency distributions are useful when we are interested in the cumulative standing for a particular variable.

For example, suppose, the administrators of a large social service agency want to study the problem of staff absenteeism.

They would like to identify seasonal patterns that may exist and that could possibly be reduced through new policies on vacations and annual leave.

Based on a total of 200 lost staff days, Table 2.13 shows cumulative percentages for a four month period.
What can you determine from this table?

Table 2.13
Cumulative Percentage Distribution Table:
Staff Days Lost by Month at XYZ Agency

Monthly Totals	Absolute Percentage	Cumulative Percentage
April	15	15
May	20	35
June	30	65
July	35	100

HyperStat Help

Data

Variables

Values

The variations for a variable are referred to as the variable's values. For example, male and female are the two values for the gender variable.

DATA AND VARIABLES

Many of our practice activities involve collecting and organizing information about various aspects of our profession and about our clients. Practitioners and researchers from all professions engage in some form of information gathering. Our profession uses a wide variety of research methods to collect information. We use surveys, interviews, content analyses, experiments, and direct observation of behavior in natural settings. In addition, we use existing information already

Click here to return.

Hints

See Also

Step 6: Flowcharting the Lesson

A flowchart is a series of diagrams that describe in detail what operations a computer should perform and in what order it should perform them. While the flowchart does not include the actual text and pictures for the lesson, it should include all details of the sequence of lesson components, such as information presentations, questions, student interactions, and student choices. The flowchart also includes information about when the computer will draw or animate pictures, what happens when the student makes mistakes, and when the lesson should end. Because flowcharting requires a great amount of detail, we suggest a series of draft flowcharts. After the final flowchart is produced, including all the necessary details of lesson part and sequence, programming can commence.

For **HyperStat** this stage did not represent a distinct step just prior to programming. Rather, this stage more closely constituted a final refinement of flowcharting begun during initial idea generation for the lessons. This was primarily due to the critical nature of **HyperStat**'s interface. It was felt that two factors - the emphasis on an object oriented environment and the use of hypertext capabilities - in **HyperStat** made the logic and interface of the program pivotal. Therefore, discussions of the flow and operations of the program were begun much earlier than might otherwise have been the case.

During this phase the author finalized a series of detailed flowcharts, showing in detail the sequence and logic of the **HyperStat** program. This included the initial interface, module sequencing, testing procedures, and help routines. Finally, the flowcharts also detailed the location of various graphics to be included in the program, although this did change as programming was conducted.

Step 7: Programming the Lesson

Programming is the process of translating what you have on paper into a series of instructions understandable to the computer. The program is produced directly from the flowchart and the storyboards. Although programming manuals make a number of suggestions on how to go about programming and how to avoid errors, programs inevitably contain errors after they are written. The last part of programming, therefore, involves checking your program for mistakes and making changes until it does exactly what you want. This final process in commonly known as *debugging.*

HyperStat was programmed over a period of months by the author, using Plus 2.0 (Plus, 1990). The process included continuous refinement of **HyperStat**'s interface, displays, help system, and quiz systems. As well, many graphic components for the program were designed and produced by the author.

Programming the lesson proved to be a prolonged process. In total, **HyperStat** contains approximately 2500 lines of written code. Few of these lines are found in single, lengthy segments of code. Rather, as each screen contains multiple objects, which individually possess specific code, much of the programming occurred in small, discrete segments. As well, occasional difficulties were encountered due to the fact that the application development platform is a new product. A number of the programming routines required to create specific **HyperStat** functions had to be learned by trial and error. Thus, it is estimated that the programming for **HyperStat** required approximately 350-400 hours. A sample of programming code may be seen on the following page.

Debugging efforts began through preliminary use of the program by fellow students, and by program reviews on the part of the thesis supervisor. Information gathered at this point lead to corrections of programming errors missed during prototype creation.

Figure 4.3
A Sample of **HyperStat** Programming Code:
A Routine to Score and Total Quiz Answers

```
On openCard
 set lockscreen to true
 add cd dbfield "q1" to cd dbfield "total"
 add cd dbfield "q2" to cd dbfield "total"
 add cd dbfield "q3" to cd dbfield "total"
 add cd dbfield "q4" to cd dbfield "total"
 add cd dbfield "q5" to cd dbfield "total"
 show cd dbfield "total"
 global gname
 set the textfont of cd wpf "name" to 3
 put title(gname) into card wpf "name"
 set lockscreen to false
End openCard
```

The above example of programming code is a typical example of object oriented programming code in Plus 2.0. The script is executed upon moving to or opening a screen, otherwise known as a card. Once the card has been opened, the screen display is locked while a number of functions occur. Firstly, correct responses for five quiz items, which have been previously recorded in data base fields, are added to a data base field known as "total". This total is then displayed as part of the screen. Next, a global (program wide) variable called gname is recalled from an earlier portion of **HyperStat**. This represents the student name entered upon entry into the prototype, and creates a sense of personal interaction. The value for gname is placed into a word processing field simply called name, and displayed in a particular bold faced font. Finally, the screen is unlocked and the final screen composition is displayed for the user.

Step 8: Evaluate the Quality and Effectiveness of the Lesson

In this last step the designer evaluates the lesson with an eye toward how well the lesson looks and how well it works. To assess how well the program looks the designer and others experienced in teaching and instructional design use program - a process called *instructional review*. Assessment of how well the program works is accomplished by observing the results of real students studying the lesson. This process includes both *pilot testing* and *validation*.

Assessment of how well **HyperStat** looks has begun, with reviews by the thesis supervisor and other personnel in the Faculty of Social Work at the University of Calgary. As well, the program was reviewed by the authors of the text *Statistics for Social Workers*. Finally, the program was displayed in a professional context at two recent social work conferences, with the intent of receiving feedback on the content and functionality of **HyperStat**.

It should be noted that assessment of how well the program works is beyond the scope of the current study. Therefore, pilot testing and validation of **HyperStat** remain future endeavors for the author of this thesis.

<u>SUMMARY</u>

In this section we have outlined the structure, content, and development process of **HyperStat**, the prototype ITS for statistics. This included the purpose of the application (to teach introductory statistical concepts), the selection of a substantive basis for the ITS

Statistics for Social Workers), the selection of an object oriented application development software (Plus 2.0 for personal computers), and the design model and procedures utilized in the development of the prototype.

The following section provides a summary of the findings of the research undertaken in this thesis. This includes a summary of the current state of statistical instruction within social work; and findings related to the development of the prototype ITS. As well, implications of the study's findings for social work theory and practice are outlined; and, directions for future research are suggested.

CHAPTER FIVE

CONCLUSIONS AND IMPLICATIONS

This final chapter is written subsequent to the development of **HyperStat**, the prototype interactive tutoring system (ITS) for statistics. As such, it provides a summary of the findings of the research undertaken. This includes a summary of the current state of statistical instruction within social work; and findings related to the development of the prototype ITS. As well, it outlines some of the major implications of the study's findings for social work theory and practice; and, suggests some directions for future research.

INTRODUCTION

From the literature, this thesis has shown that deficiencies in traditional statistical training techniques have resulted in social workers who are ill equipped to conduct professional social work practice. Therefore, it can be suggested that traditional methods of statistical instruction are ineffective in teaching social work students. For this reason social work educators must explore ways to correct the deficiencies of present statistical instruction. Based on just such a premise, the thesis had the following objectives.

Objective 1:

To establish the current state of statistical instruction in social work.

Objective 2:

To develop a prototype interactive tutoring system (ITS) for statistics.

The following sections offer a brief summary of the conclusions drawn regarding each one of these objectives. We begin with a discussion of the current state of statistical instruction in social work.

STATISTICAL INSTRUCTION IN SOCIAL WORK EDUCATION

Despite the move to scientifically based practice in social work, evidence exists that suggests social workers remain unable to utilize an empirically based mode of practice. Researchers have concluded that social work practitioners are ill equipped to consume, produce or disseminate quantitatively based research. For example, the literature advises that practitioners have little exposure to research-based practice literature, and are generally unable to evaluate its methodological soundness or draw implications for practice (Kirk & Fischer, 1976). Moreover, practitioners typically are not conducting empirical studies of their interventions, using research findings in their practice, reading research articles, or assessing research findings critically (Siegel, 1983).

It has been also been argued that most MSW practitioners probably do not possess even a minimal understanding of research terminology requisite to an informed utilization of research findings (Lawson & Berleman, 1982; Kirk & Fischer, 1976). In particular, only a small minority of social work articles are based on research. As well, those that are provide examples of the gross misapplication of applied statistics and inappropriate research design. We must conclude, therefore, that research and statistics education in social work is, in fact, questionable.

In an exploration of the roots of these problems, the author focused on the educational process involved in the statistical training of a social worker. In fact, the literature does suggest that the statistical training of social workers is deficient. The study found that social work educators are unsure of how to integrate research/statistics into social work curricula. When research/statistics is introduced into social work curricula, it often utilizes traditional instruction methods - instruction methods which are inflexible, authoritarian and based upon memory. It is a traditional, flawed method of learning statistics by rote means. Students' lack of real conceptual understanding, based upon rote learning, quickly results in statistics being forgotten (Weinbach and Grinnell, 1987).

All of the above represent a series of effects that are the product of inadequate research and statistical training in social work. These effects include an inability to adequately review and critique social work research, and an inability to produce and disseminate social work research. It has been suggested that the above evidence demonstrates the need for an alternative approach to statistical instruction. Social work educators argue for a new mode of instruction based on innovative educational principles, such as an emphasis on problem-solving, creativity, and individuation of learning. These axioms include a focus on basic, core concepts of statistics, a critical problem solving approach to instruction, an emphasis on developing innovation and creativity, the integration of research and statistics into practice, the role of individuated, adult styles of learning, and the need to introduce computer technology as a component of statistical instruction.

Considering this inherent integration of statistics and computers, it is only natural to consider the utilization of computers as a tool to enhance statistical instruction. As argued in the thesis, the current marriage of statistics with very limited exposure to computer course work poses difficulties for students and educators alike. Without a concurrent exposure to computers and the diversity of computer applications, training in such areas as statistics is only partially successful. Typically students experience unpleasant associations toward statistics in general, and when mated with computer technology a compounded, phobic-like reaction occurs. Together, these reactions ensure that both statistical competency and computer literacy suffer (Parker et al., 1987).

However, the literature does suggest a promising alternative that may enhance both statistical comptenency and computer literacy goals. This alternative is computer assisted instruction - the utilization of computer hardware and software in the conceputalization, design and implementaiton of the instructional experience. CAI has been shown to address a number of the limitations that currently exist in contemporary statistical instruction techniques. It offers an interactive basis for learning, a chance for students to gain "hands-on" computer experience, a highly accepted basis for learning, and a cost-effective means of delivering instruction. Moreover, studies show that it allows for a self-paced, individuated style of learning, and opportunity for self-assessment. As well, it provides effective positive reinforcement, patience, innovative and creative exploration of substantive areas, and the ability to simulate complex situations. Finally computer assisted instruction may be utilized in problem solving endeavors, offers easily modified data manipulation, and is easily intelligible to the novice user.

Quite simply, then, computer assisted instruction does offer statistical training capacities that can strengthen the learning process. It offers the capability for a critical problem solving approach to instruction, for innovation and creativity in the instructional process, for building practice scenarios into the research process, for structuring individuated, adult styles of learning, and for meeting the mandate of introducing computer technology to social work education. For these reasons computer assisted instruction appears to address the deficiencies found in traditional statistical education.

HYPERSTAT - THE PROTOTYPE INTERACTIVE TUTORING SYSTEM (ITS)

The second objective of this thesis was to demonstrate the benefits of information technology, or more specifically computer assisted instruction, as an aid to traditional methods of teaching statistics.

As CAI is relatively new to the educational process in social work, however, examples of CAI are extremely limited. Therefore, the achievement of the second objective focused on the development of a prototype interactive tutoring system (ITS) - called **HyperStat** - that demonstrated the benefits of computer assisted instruction as a vehicle for strengthening statistical instruction in social work education. From the development of this prototype, two topics of discussion emerge. These topics include:

1) the challenge of CAI development faced by social work educators; and

2. the utility of **HyperStat** and similar ITS software for social work education.

THE CHALLENGE OF CAI DEVELOPMENT

The development of any CAI software, and particularly that of an ITS, poses a number of challenges that must be addressed. Many of these became readily apparent during the creation of **HyperStat**. One of the first issues to emerge is time. It is impossible to predict in precise terms just how long it takes to develop a program. However, in consideration of the 350-400 hours required for the author to develop this protoype, a full fledged program may be a monumental task. The author therefore must agree with Wilson (1985), who suggested that the development of CAI consumes much more time than planning conventional instruction (Wilson, 1985)

It is evident that development time may be influenced by a number of factors. Inexperienced software authors will obviously take much more time than those who have previously completed the process. Above that disctinction, however, one also must be aware of how well the substantive content is structured for incorporation into a CAI application. If the content already exists in a suitable self-study format, perhaps fifty percent or more of development time may be saved. Otherwise, a software author could possibly expect to double the time required for software development, and will likely not begin actual computer programming until after countless hours of conceptualization have already been spent.

A third factor to consider is the relative complexity of the application. The author concurs, possessing a new found sense of appreciation, with Berven (1985) who argues that compared with other forms of CAI, tutorials can be much more complex to design and program. It is obvious to the author that they generally require a powerful authoring system or programming language to design and write the application. For example, a linear presentation of text material that offers no graphic images or colour would be much easier and faster to create than an object oriented, hypertext based software. The design and production of graphics, linking of concepts, creation of program symbols, and so on are time consuming tasks. Therefore, the more "bells and whistles" the author wishes to build into a program, the more time, effort and expense will be major factors. These capacities for sound and graphics capabilities, and the ability of the CAI application to incorporate branching would likely represent a complex, intensive effort on the part of all software developers.

Finally, the time required to create a CAI software application will depend largely on the development platform chosen. The selection of an authoring system designed for CAI development does offer advantages. Many of these systems allow the educator to simply insert educational information into predetermined formats to create a CAI lesson.

However, this process imposes a structured, inflexible format onto both the educator and his/her content. The more flexible and therefore creative possibility is to use a true programming software to construct a CAI program. This flexibility to create, though, also carries a distinct disadvantage in terms of the time and expense required to produce quality computer-based instruction. Innovation and creativity are going to cost time.

Another principle that became to the fore during the creation of **HyperStat** is that software development should ideally be conducted using a team approach. The process of development demands a diversity of skills and knowledge. In fact, a significant portion of time was spent by the author in attempting to acquire the required range of skills necessary to develop **HyperStat**. First of all, a knowledge of the substantive area is an intrinsic determinant of quality CAI lessons. It forms the foundation of any CAI software. Above that, at least a basic knowledge of computer systems, and software applications in general, must be developed so that the educator can work within the frame of reference mandated by the area of CAI. It is also essential in working with other professionals in the field. If the educator chooses to pursue CAI development individually, he or she must cultivate skills in instructional design, computer programming, graphic design, validity testing, and so on. Very few individuals possess all of these skills, and fewer still would have the time required to develop them fully. Thus, in order to design and produce a complete and high quality CAI application would almost certainly require a team of skilled personnel.

As a final comment, it must be noted that the author considers tools for CAI development to be undergoing a series of major transformations. As computers and computer software evolve more and more rapidly, so too will the tools available to educators wishing to pursue CAI development. For example, Plus 2.0, the software platform for **HyperStat**, represents a significant advance in capacities available to software authors. This presents the educator interested in creating CAI applications with a powerful vehicle. However, it is a platform faced with serious limitations. It requires a personal computer that utilizes a powerful, fast micro-processor. It also requires a considerable amount of RAM (Random Access Memory) memory to function with any degree of utility. Therefore, any software developed using this platform also requires these hardware capabilities. In effect a substantial portion of the personal computers currently in use would be unable to run **HyperStat** or similar software.

Despite these problems, the author considers such limitations as temporary in nature. Continuing advances in computer hardware and software development tools will make CAI both more powerful and more accessible. Increasing capabilities to incorporate faster computers, devices such as CD-ROM disks, improved computer displays, improved graphics abilities, sound, and improved programming languages will make CAI more feasible for all educators.

THE UTILITY OF HYPERSTAT AND RELATED ITS SOFTWARE

The final assessment of any software application lies with the user. This is particularly true in the case of CAI applications. Therefore, in a sense the utility of **HyperStat** has not been fully established. Assessment of how well the program works is accomplished by observing the results of real students studying the lesson. This process includes both *pilot testing* and *validation*. It should be noted that assessment of how well the program works is beyond the scope of the current study. Therefore, pilot testing and validation of **HyperStat** remain future endeavors for the author of this thesis.

However, based on current subjective evaluations, initial conclusions may be drawn regarding **HyperStat** and perhaps similarly structured ITS software. These assessments are based on an instructional review.

Again, to conduct instructional review is to assess how well the program looks. The designer and others experienced in teaching and instructional design use the program with an eye toward its apparent value - a face validity so to speak. In the case of **HyperStat** this included reviews by the thesis supervisor and other personnel in the Faculty of Social Work at the University of Calgary. As well, the program was reviewed by the authors of the text *Statistics for Social Workers*. Finally, the program was displayed in a professional context at two recent social work conferences, with the intent of receiving feedback on the content and functionality of **HyperStat**.

In all cases the instructional review has been favourable for both the possible merit of ITS applications for social work education, and for **HyperStat** itself. These judgments have typically focused on a few basic topics - the general context and premise of such software, the use of graphics, the use of hypertext, and the advantages of object oriented programming. We will briefly discuss each in turn.

The first type of comment expressed during the instructional review of **HyperStat** centered around the general context of ITS applications. Using **HyperStat** as a guide, some reviewers quickly identified other substantive areas suitable for such a software. Moreover, there was a general agreement that such ITS packages could provide an objective medium for instruction, a medium that offers rapid access to vast amounts of instructional material. Most reviewers felt that, while such a software could never be the sole source of learning, a quality ITS application could offer a valuable suplement to traditional education. The opportunities for flexible and interactive education, student-paced learning, studying during irregular hours, possibilities for diagnostic feedback and a means of testing were all cited as supplemental functions for ITS packages.

A second type of comment revolved around the use of graphics. Graphic images are a critical and distinguishing feature of **HyperStat**. The author believes that we are very much a society accustomed to messages, symbols and images from multi-media sources. In fact, illustrations are an intrinsic component of many information and communication networks. Therefore, to engage and retain the interest of students requires more than text alone. As evidence, it was the graphic images in **HyperStat** that first caught the attention of most reviewers. Many principles in **HyperStat** proved much easier to demonstrate with one simple graphic. On a broader scale, the use of graphics in ITS applications offers much promise. Graphics are applicable to a wide range of substantive areas and tutoring systems. In time high quality images will undoubtedly be an integral component of all CAI applications.

The third general comment regarding **HyperStat** and related applications dealt with the concept of hypertext. Reinoehl (1990) contends that ITS offers learners more control to direct the unfolding of the learning interaction, hence the shape of the learning. In a very real sense the learner is perceived as "an active agent whose cognitive structures are undergoing change as he interacts with a learning system". This principle was in fact unknown to some reviewers. However, the author is convinced that highly flexible and interactive elements (built into **HyperStat**) can be enhanced by the use of hypertext links between related topics. It is therefore very possible to create a standard means of exploring the same information, even though the reader may have very different preferences or learning styles. The presence of hypertext in an application still allows a flexibility to allow students to move from once concept to another easily. In fact, the author believes that this is the future of information processing. Users will not follow the standard, front to back means of exploring the same information. Instead, much information will be hypertext based - utilizing multiple pathways (structures, branches, or alternatives) by which the user can explore individualized paths or lines of inquiry through any application. In effect, each user will be offered a unique presentation of the material at hand.

It should be noted, however, that the use of hypertext requires extensive conceptualization and programming of the part of a software designer. In any substantive area a large number of concepts are inevitably linked to one another. To create the branching and linkages necessary for hypertext-based learning to work requires two factors. The software author must conceputalize and draw the connections between each of these topics - a substantial job in itself. Then, the author must utilize a rather powerful programming lanuguage to program the hypertext structure in the software. This again could be a formidable task.

The final series of comments regarding **HyperStat** and related ITS applications are of most value to other eductors wishing to explore similar software. Object oriented programming does appear to represent a valuable programming tool for CAI software design. Because object oriented programming enables a non-linear form of programming, it integrates very well with hypertext. Moreover, the author found the capacity to build functionality into distinct objects (such as graphic symbols, words, numbers, screens, and lists) allowed a tremendous degree of freedom to design an innovative ITS. As well, it greatly simplified the programming of **HyperStat**. Object oriented programming allows the programmer to select distinct portions of an application (e.g. particular objects), and reuse them. For example, once the "Help" button was created for the first **HyperStat** lesson, it was a relatively simple matter to copy it to another lesson.

Of particular value to the author was the ability to send a "message" to a particular object. A message is simply a signal to an object to return some information about itself, or to carry out an action. In fact, everything in an object oriented environment happens by one object sending another a message (Shafer, 1989). For example, the author was able to write a sequence of code that allowed the user to "click" on an image of a computer to get help about using **HyperStat**.

A final note regarding object oriented programming must be made. The author believes that in the future the strongest benefit of object oriented programming, may lie in the portability of programmed code. Not only may it be reused, but conceptualization and design of software may be transferable. In essence, the educator interested in CAI will eventually develop a "library" of classes, objects, and functions which may be manipulated to create a variety of software applications, regardless of the substantive area.

IMPLICATIONS OF THE STUDY

The attitudes of social workers toward the use of statistics in social work have been found to be negative and anxious. Perhaps more importantly, the literature also suggests that social work practitioners do not possess the capacities to adequately consume or produce statistical analyses as part of their professional practice. In view of these problems, the drive for an empirical base for social work is unquestionably compromised. If, as Weinbach and Grinnell (1991) argue, statistics provide social workers with an understanding of the concepts underlying sound social work practice, the lack of statistical comprehension must hinder their understanding of basic social work concepts. Moreover, lack of statistical capabilities must prevent social workers from developing an understanding of how knowledge for practice decision making is generated and evaluated.

Ultimately, a solid development of the profession's knowledge base will fail to emerge, and social work may remain heavily dependant on the other social sciences for our own principles. In effect, without a sound statistical foundation, social work will be unable to establish its own accountability, its own identity.

As a means of addressing these issues, the study aimed to demonstrate the benefits of information technology, in the form of computer assisted instruction (CAI), as an aid to traditional methods of teaching statistics. The development of an interactive tutoring system for statistics, called **HyperStat**, allowed the author to explore a supplemental method for teaching statitics to social workers. This exploration found that social work educators can develop ITS applications. Moreover, the software created by educators need not be defined by external sources. In other words, the instructional process, even though computer-based, does not have to be a foreign, rigid environment for the educator. Information technology has advanced to the point that social work educators have ready access to powerful, easily learned application development platforms. This allows them individually, or as an integral member of a team, to conceptualize and produce innovative CAI software. Such capacities will continue to expand as information technology continues its rapid evolution.

As a result, the author foresees a reshaping of traditional instruction in social work. Social work can and should explore the promise that CAI offers for non-linear thinking, creativity, individuation of learning and problem-solving. In fact, it would be a matter of some concern to the author if social work should fail to explore the possible benefits of CAI. As a promising means to reinforce instruction of basic concepts, CAI offers educators an opportunity to better prepare practitioners for professional practice. This is true not only for statistical instruction, but likely a wide range of other substantive areas as well.

Again the author refers back to the belief that we are very much a society accustomed to messages, symbols and images from multi-media sources. Linear, text-based material often cannot convey the complexities of many social work principles and procedures. Therefore, to engage and retain the interest of social work students, and communicate abstract concepts requires more than text alone. Object oriented and hypertext based programs will accomodate very different preferences or learning styles in the learning of social work material. A profession which prides itself on flexibility, individuation, and problem solving must pay attention to tools that offer just those capabilities. Social work educators, mandated by their own professional framework, will in time allow students the chance to explore individualized paths or lines of inquiry through the use of social work CAI applications.

On a specific level, information gained from the development of **HyperStat** extends to educators useful techniques for developing alternative methodologies for the teaching process. In effect, the development of the prototype may offer social work an introductory look at a new tool of instruction. It is a tool that offers much utility for strengthening the teaching of statistics, and may eventually promote statistical competency among social workers.

Once social workers do become more adept at statistical analyses, the knowledge generated by these analyses can be incorporated into the theory and practice base of human service practitioners. It is critical for practitioners to develop statistical competency and to be confident in its use. By possessing such skills they can not only work effectively in their own settings, but also be involved in the development and dissemination of a wider knowledge base. The result will be a stronger social work profession.

DIRECTIONS FOR FUTURE RESEARCH

On a broad level, the author's experience with CAI and specifically ITS applications have been positive. It is somewhat of a mystery, then, why social work has failed to adequately explore the use of CAI. Research needs to be undertaken on how CAI can benefit social work instruction, how to best develop CAI applications for social work, and how effective CAI is for social work instruction. With our society's unhindered movement into a technological base, social work has a responsibility to explore the use of information technology in teaching future professionals.

Secondly, while initial perceptions are positive regarding the development and utility of **HyperStat**, many questions are left unanswered by its current state. The most obvious of these questions is a simple one. Does such a program work? Pilot testing and validation of **HyperStat** are the next step in verifying the utility of such software for statistical instruction in social work. Research needs to be undertaken to discover just how effective **HyperStat** is a a vehicle for statistical instruction.

From this perspective the thesis has pointed to a final area for further research. Research has shown that social workers remain unable to utilize an empirically based mode of practice. Social work practitioners are currently ill equipped to consume, produce or disseminate quantitatively based research. Further research needs to be undertaken to discover why and how social work education has failed to adequately prepare practitioners for professional practice. This is perhaps the most critical aspect of further research endeavors. If answers can be found, educators may better enhance the understanding of how knowledge for practice decision making is generated and evaluated. Ultimately, the solid development of the profession's knowledge base can be strengthened, and social work can better establish its professional identity.

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