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Investigation of comparative effectiveness of intelligent computer assisted instructions on the achievement of Jordanian freshman students

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INVESTIGATION OF COMPARATIVE EFFECTIVENESS
OF
INTELLIGENT COMPUTER ASSISTED INSTRUCTIONS
ON
THE ACHIEVEMENT OF JORDANIAN FRESHMAN STUDENTS

SAADAT FARIS HASSOUNEH

MAY 21, 1987

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ABSTRACT

This is an investigation into the effectiveness of Intelligent Computer Assisted Instructions technology on the achievement of Jordanian Freshman students. An experiment was desinged for this purpose which employed "time seriss measures non-equivalent experimental control group design". The population of the experiment was the entering freshman students registering for course Computer Science CS103 in fall semester of 1986. Two "non-equivalent" qroups were chosen, an experimental group or E-Group and a control group or C-group. The E-group (25 students) was chosen randomly from the total population of 848 students. The balance of the population constituted the C-group. The experimental design tested the hypotheses:

1. HO: There is no statistically significant difference in the mean of the multi-variate vector of the achievement and attitude test scores of students taught by the ICAI method and the traditional lecture method.

2. H1: The mean of the multi-variate vector of the attitude and achievement test scores of students taught by the ICAI method is greater than that of the traditional lecture method.

The independent variable of the study was the teaching method (ICAI and Traditional). The dependent variables were achievement and attitude of the students of the population.

A computer program using ICAI technology was developed using an IBM micro and was used in the procedure for the ICAI method of teaching with the E-group. The other method of teaching was the traditional classroom method. Standard tests of achievement were prepared jointly by all teachers. Three achievement tests were given, the first was given six weeks from the start of the semester, the second was given six weeks after the first and a final test given at the end of the semester. Attitude questionaire was filled by all students at the same time of the final acheivement test.

Analysis of the achievement scores and the attitude questionaire were done using the SPSS computer program running on the VAX-11/780 System. The analysis showed that the ICAI method of instruction mean scores were significantly higher than those of the traditional method. The multivariate null hypotheseis of no treatment effect is strongly rejected. The effect of sex was also tested. Treatment by sex clearly showed no interaction effect due to sex.

The results of this study clearly reject the null hypothesis of method effect (no differences in achievement scores of students taught by the two methods) in both the

MANOVA as well as in the ANOVA conducted separately on the total achievement score. Moreover, in the comparisons based upon all the 823 students taken as contral group, the experimental group (ICAI group) scored significantly higher on the total of the three tests.

The effectiveness of a tutoring system is universally assessed in terms of students achievement test scores, at times, supplimented by their scores on measures of attitudes and feelings. On both counts, the findings of this study speak unequivoncably for the effectiveness of the ICAI method.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Artificial Intelligence as a science has developed some techniques that provide an "Intelligent" approach to the learning process through computers. This is one investigation into Intelligent Comptuer Aided Instructions which contain "expertise" on the domains they are teaching. Systems built on the basis of such research allow two-way interaction. The student can pose problems to the system to see how they can be solved, as well as the system setting problems for the student. Using its knowledge base, the system can also explain where the student is going wrong.

Intelligent systems can also maintain a student model, which contains information about what the student does and does not know. Using this model the system can then guide its teaching strategy in such a way as to provide more information in areas where the student needs more training. As the student learns and answers questions the system updates the model (revises its belief of what the student knows or does not know), thus keeping up with the students progress.

This is in contrast to the conventional approach to computer aided training where a pre-defined text is presented to the student and his/her understanding is assessed using pre-defined question and answer. Such systems suffer from lack of flexibility and are not responsive to students needs. They lack three features of human learning situation that are fundamental to the effective transfer of knowledge and skills to students: knowledge of the student, knowledge of the subject matter, and mixed initiative dialogue.

We will see in a later chapter a description of ICAI systems which have been tested in environments of Western culture. In my review of the literature I was not able to find any ICAI systems that have been developed for testing or use in Jordan schools. It has been well recognized that the cognitive processes, styles and the way people think and behave are to a great extent determined by cultural and ecological factors. This implies that what holds for Western culture may not necessarily hold for Arab/Islamic culture. Therefore this study is specifically designed to test the effectiveness of ICAI systems with Jordanian university students. Jordan is an Arab/Islamic country which emphasizes education. Testing ICAI systems in Jordan with the aim of using such systems in situation learning will be very useful.

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1.1.1 STATEMENT OF THE PROBLEM

Research has produced some general principles and theory of ICAI , however the application of these principles and theory did not receive enough testing and have been tried on a limited scale (Barr,Fiegenbaum and Cohen, 1981). One can state that all ICAI is in a pioneering stage of development. The potential offered by ICAI has hardly been applied and testd with the vast variety of problems in education. This is true in the Western world and is particularly true in the developing countries such as Jordan where nothing has been done.

The very notion of ICAI is a novelty which many education specialists find hard to grasp. Nevertheless, Jordan has committed itself to update and modernize its system of education. Within this framework the use of computers in the many applications is being encouraged particularly in the field of education.

The focus of this research is on the applicability of ICAI in the context of Arab/Islamic culture in general and the Jordanian educational process in particular. More specifically this study intends:

1. To develop an ICAI computer program using an expert system shell for a unit of instruction in the introduction of computer science.

2. Test the ICAI program with university freshman students.

3. Investigate the program's comparative effectiveness in terms of students' achievements.

Formally stated, the problem of this study is to establish the effectiveness of ICAI techniques in comparison with the traditional lecture method on Yarmouk University freshman students in computer science course 103. Effectiveness here is operationally defined as the achievement of the students of the course objectives. Achievement is measured by an achievement test constructed for this course by a team made up of all the instructors teaching the course during the semester (fall 1986) in which the experiment is conducted.

1.1.2 SCOPE OF THE STUDY

The education system of Jordan requires a comprehensive examination of all graduating seniors of high schools in the country. Students are then classified as "arts" or "science" students based on their scores in the comprehensive examination. They are also admitted to universities based on such classification. Thus science students are admitted to technical colleges and arts students are admitted to non-technical colleges competitively on their standing in the comprehensive test. Yarmouk University requires that all entering freshmen take an introductory course in computer science. However the introductory course taught to arts students has different objectives from that of the course taught to science students. This investigation concerns and works with arts entering freshmen students only. The course to be used by this study is the computer science course 103 taught to arts freshmen students at Yarmouk University (fall, 1986). The study also, is limited to the use of the artificial intelligence techniques of knowledge-based expert systems using a consultation tutoring strategy. The study also is limited to the measurement of achievement as measured and defined by the test during and after the completion of the course.

1.1.3 BACKGROUND

This study requires understanding and background in Artificial Intelligence and learning theory and applications. The following few paragraphs present the areas of expertise one needs in order to carry out and understand this investigation.

Scientists have often dreamt of developing machines that apply reasoning processes very much like those of the natural human mind. Modern computers can perform calculations at speeds far beyond the imagination of humans, yet they are incapable of even the simplest reasoning activity. Research is being carried out to enable modern computers to immitate the processes of the human brain. This research called "artificial intelligence" has come to be known as that part of computer science which investigates nonalgorithmic reasoning processes and the representation of symbolic knowledge for use in machine inference,(Minsky, 1975).

The core question about artificial intelligence is "can machines really be taught to reason, to think and to apply common sense very much like humans do?". The more scientists tried to look at the issues the more they realized the difficulty of separating science from science fiction.

It is true that modern computers perform precisely defined tasks with speed and accuracy. However machines do not possess what we refer to as "common sense" in humans. The human mind while incapable of complex computations is quite able to understand and reason. We humans may think a computer is intelligent because it can solve complex problems of structures or nuclear physics, whereas in reality the machine may neither understand the problem nor comprehend the meaning of intelligence,(Weizenbaum, 1979). It is in trying to make the machine apply sensory techniques and understand and reason like humans that scientists are doing research in artificial intelligence.

But how are scientists approaching the subject of developing machines that do reason very much like humans? There are two approaches; performance and simulation.

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Performance may be illustrated by imagining a mathematician embarking on a project to develop a poker-playing computer program. He is likely to design a program that is based on mathematical and statistical techniques. The result would be a program that would maximize its chances of winning by playing the odds, bluffing at random and show no emotion. The mathematicians program would be concerned with the objective of the final result or the final performance of the program. Such an approach is said to be performance oriented.

Simulation can be illustrated by assuming that the same project was given to a psychologist. He would likely design the poker-playing program using theories of human thought and behavior. The program might even have several routines. One might play the game agressively while another is easily intimidated. The program may even be emotionally involved in the game and lose everything it owned. The approach of the psychologist is to understand the processes of natural intelligence. The project then will be geared towards testing theories by building computer models based on such theories. This would indicate that the objective of the intelligent program is only a means to reach another objective namely that of understanding human thinking and behavior. Using such techniques is said to be simulation oriented.

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Scientists seem to be making contributions to AI using performance and simulation techniques. However, elusive philosophical questions persist. Consider for example the discussions generated when one asks (How is intelligence measured, by the amount of winning or by exhibiting humanlike qualities?). Such questions arise from the fact that it is often difficult to distinguish between the appearance of intelligence and its actual existence. Intelligence in fact is an internal characteristic that can only be detected through the use of stimulus/response dialogue. Realizing this difficulty scientists have tried different approaches to detect intelligence. One such scientist is Alan Turing who proposed a test for detecting machine intelligence. His proposal was to allow a human interrogator to communicate with a subject by means of a computer terminal without informing the subject whether he is communicating with human or computer. If the subject was unable to distinguish the machine from the human then the Turing test would have been passed by the computer.

The Turing test was implemented in the mid sixties. Joseph Weizenbaum (1966) designed a computer program that would project the image of a Rogerian analyst conducting a psychologist's interview. The computer played the role of the analyst and the user of the program played the role of the patient. The program known as "DOCTOR" worked according to well defined rules and directed them back onto a computer terminal using a screen interactively. DOCTOR rephrased some of the statements made by the user and if it was not able to recognize its structure then it would respond with phrases such as "go on" or "that is interesting". The main objective of Weizenbaum was to research the area of natural language. The subject of psychotherapy was to play a secondary role in the experiment. However some therapists used DOCTOR to conduct actual therapy. This practice was criticized by some as unethical and immoral while others have encouraged it and called for more work. The ethical and moral issues will be debated for some time. The therapists argued that the Rogerian therapy stressed the importance of patient leading the sessions rather than the therapist and therefore a computer could conduct a session as well as a therapist. Also DOCTOR projected the image of comprehension so strongly that many who used it found themselves projecting intimate thoughts and feelings, and in many instances actually becoming subservient to the computer's dialogue.

An approach to AI is taken by some workers in the context of programming science (Boden 1977). Anyone concerned with the field must refer to programs and programming. Yet programming does not interest many who are making sizable contributions to the domain of AI. Philosophers, psychologists, linguists, information theorists, even programming experts consider the activity as subordinate to a much wider aim, such as "the development of a systematic theory of intellectual processes" or "the study of intelligence as computation", (Michie, 1974). Such concepts stress intelligence in general, not human thought processes in particular.

Another approach is taken by those who concentrate on the technological innovations. These take the form of projects such as developing a robot, a chess playing program, a speech synthesizer, an automatic clerk, an intelligent tutor... These workers describe AI as "an engineering discipline",(Nillson, 1974). This of course does not appeal to those with psychological interests.

There is evidence, however, that psychology and AI are related. The knowledge we acquire about human intelligence, suggests and extends the theory of machine intelligence. What we learn about machine intelligence could also suggest something to us and therefore increrase our knowledge of human intelligence. The relationship between human and machine intelligence is therefore "symbiotic". This is nowhere more evident than in the works of Allen Newell and Herbert Simon. They developed a theory of problem solving called LT "(Logic Theorist)", which they implemented as a computer program. They modeled the "problem-solving" behaviors they expected to find in human problem-solvers, (Barr, Feigenbaum and Cohen, 1981). When later they tested their theory, it failed because they found that humans did not use the same control process as their model. They learned about human control processes during solving problems and incorporated this new knowledge into their computer programs. The new control process is known as "means-ends analysis" and the program as General Problem Solver (GPS).

Theoretical and application oriented research has been carried out by AI researchers. Following is an outline of theoretical and applications research.

1.1.3.1 THEORETICAL Research -

Theoretical work of AI has been concentrated in the following subfields of AI:

1. Models of cognition

2. Automatic deduction

3. Computer vision

4. Learning and Inductive Inference

5. Natural Language nuderstanding

Applications oriented research deals with the following areas:

1. Science

2. Medicine

3. Automatic programming

4. Education

1.1.3.1.1 MODELS OF COGNITION - Cognitive models are embeded in "cognitive science" which deals with "Understanding human behavior". They are devoted to models of problem-solving human memory, and belief systems.

Newell and Simon have thoroughly researched "human problem-solving". Their GPS program is so powerful and made such an impact that it is worth mentioning. The program (GPS) has distinguished task-specific knowledge from general knowledge (Newell and Simon, 1972). An illustration would be a general rule, or heuristic, such as"If you can't solve the whole problem, try to solve part of it". A specific piece of knowledge that may be useful for solving some geometry problems is,"the square of the side opposite the right angle of a right-angled triangle is equal to the sum of the squares of the other two sides". The distinction is described best in Newell and Simon:

"GPS obtained the name "general problem solver" because it was the first solving program to separate in a clean way a task-independent part of the system containing general problem solving mechanisms from a part of the system containing knowledge of the task environment (Newell and Simon, 1972)."

GPS solves problems by transforming the start state of the problem to be solved into a goal state. This is done by applying some operators to the starting state and detecting differences between states. This is known as means-ends analysis. other problem solving techniques are the EPAM (Elementrary Perceiver and Memorizer), (Fiegenbaum and Simon, 1964), and the " Opportunistic Problem-Solving", developed by Hayes and Roth, (HAYES-ROTH, 1980).

Human memory models were developed by psychologists. In natural language research computers intelligent behaviours depend on knowing meanings of words, for example, translation by computer and speech understanding. Semantic nets were developed as memory models which can be used by computers to recognize the meanings of words (Quillian, 1986). Other "human memory models" are (HAM) Human Associative Memory, (Anderson, Bower, 1973), (ACT) Active Connection Tasks developed by Anderson and is a general model of cognition, uses productions and rules used in expert systems applications (Anderson, 1976).

Theoretical AI research has dealt with the question of beliefs, because much of human discourse is in beliefs, speculations, predictions, desires,..etc. AI research deals with the structure of beliefs, how we reason with beliefs, how beliefs function as prejudices that influence interpretations, and how emotions affect reasoning. Abelson (1979) has dealt with the question of beliefs and the computational systems that have been implemented to explore them.

1.1.3.1.2 AUTOMATIC DEDUCTION -

Automatic deduction models deal with theorem proving. These models use formal logic of inference rules which imitate the reasoning of human theorem proving. There are several theorem-proving systems (McCarthy,1958):

1. Natural deduction: Models which represent proofs in a way that maintains a distinction between goals and "antecedents" and use inference rules that mimic the reasoning of human theorem-proving.

2. Resolution Rule: This model shows whether a theorem logically follows from its axioms. This is a form of poof by contradiction (Robinson,1965).

3. The Boyer-Moore Model:(Boyer-Moore, 1979) Employs mathemetical recursive function theory in which theorems are stated and are automatically proved. The recursive procedure proceeds in a forward manner continuosly

rewriting the current formula without backtracking.

4. Nonmonotonic logic model: It is known that purely deductive reasoning techniques are not completely adequate in capturing "all intelligent" thought. Statistical and inductive reasoning which dealc with inexact general reasoning have been added to supplant deductive reasoning logic. These have been recently formalized in nonmonotonic logics (McDermott and Doyle, 1980).

5. Logic Programming: Refers to a model of programming style in higher level languages. Programs are written as sets of assertions. A "logic program" consists of a set of clauses. Logic programming is useful to AI because of its powerful representations language (Robinson, 1965).

1.1.3.1.3 COMPUTER VISION -

The goal of a Computer Vision system is to understand the image of an object and identify the object whose image is projected (Roberts, 1965). Computer Vision research catagorizes the field into "Signal processing", "Classifications", and "Understanding".

Signal processing tranforms a given image into another that has more desirable properties. An example would be emphasizing the edges of a picture image to enhance details for human inspection.

Classification techniques: Information is extracted from an image then it is compared to a predetermined state to determine its classification. A decision on the "fit" of an image is made using statistical decision methods applied to "multidimensional" space. The body of theory for optimal decision rules is called "pattern recognition or classification". An example of classification techniques is "character recognition".

Understanding images builds a body of knowledge about the image. Information is extracted on "primitive features" such as change of intensity and orientation of edge elements from intensity array of the image. Also extracted are information on lines, regions, shape information, surface orientation, and occlusions.

1.1.3.1.4 LEARNING AND INDUCTIVE INFERENCE -

Learning is the process by which people and computers can increase their performance (Simon, 1969). AI researchers study learning for two reasons. One is by developing computer models of learning, psychologists are able to understand human learning. The second reason for conducting research in learning is to develop better ways for computers to learn. One of the main objectives of AI research has been the development of computer systems that can be taught rather than be programmed (Winston, 1977).

There are four generally accepted learning situations:

1. Rote learning : In this situation the information is ready. It does not need to be processed in order to be understood. All one or the computer needs to do is to store the information in his/her or its memory. An example of rote learning by the computer is Samuels checkers playing program (Samuel, 1967).

2. Learning from examples: This learning situation presents the learner (Person, or Computer System) with examples of how it should behave. The system must then find a general rule from the examples which it can use in similar situations, (Buchanan, 1977).

3. Learning By Being Told: This model uses general knowledge or advice that has been given to it in a way so as to transform this knowledge to a usable form in a particular performance. It can fill in details, make assumptions and make deductions from the advice it is given. The TEIRESIAS program (Davis, 1976) and FOO program (Mostow, and Hays-Roth, 1979; Mostow, 1981) are examples and applications of this (learning by being told) technique.

4. Learning By Analogy: This model uses a given knowledge base and tries to find an analogy to the present situation in order to improve its performance. An example would be a knowledge base about possible computer system problems or bugs. When a computer system problem is presented, the model tries to find similar problem(s) in the knowledge base and an appropriate "treatment".

NATURAL LANGUAGE

The objective of AI natural language (NL) research is to build computers that can communicate as people do. Computers communicate using rigid format languages to make it easier for compilers to parse the language. The user of these languages is constrained by syntax and meaning (semantic) of the language. Work has concentrated in developing computer programs that understand (NL) and produce "machine translation" that reflects the meaning of natural languages, and produce, appropriate text. Much research has been done on machine translation grammers, parsing and text proccessing. Early attempts at "machine translation" concentrated on translation by use of dictionary, (Booth, 1967).

Then came the concepts that say that "source text and translated text say the same thing" (Weaver, 1949). This implies, according to Weaver, that translating between languages means going from source language " to an intermediate universal language" then to a "destination language" or the desired text. These concepts did not however deal with the concept of meaning (semantics).

The early 1970s saw interest in the subject of semantics. The development of ALGOL and LISP with their features of lists spoused the development of programs that used semantics primitives that are language independent. Much current AI work on (NL) is based on the requirements that understanding of what is being said is vital to every use of language. This means that a machine translation program must first understand the subject, before it can translate the material written about that subject. The machine's ability to understand is the core question of AI research.

1.1.3.2 APPLICATIONS ORIENTED AI RESEARCH -

Much of the AI techniques and theoretical work has been applied to test the utility, the effectiveness and the correctness of concepts, to gain new knowledge about the nature of intelligence, the mind cognition, learning and reasoning. These techniques have been implemented as "expert systems ",that is computers systems that can solve complex real world problems of science, engineering, education and medicine. Systems that use large bodies of domain knowledge compiled by human experts, has proved useful for solving typical problems in their domain. Expert systems are designed to tackle problems that are difficult for human researchers to solve. These problems involved many possibilities characterized by their "Combinatorial explosion" nature, such as the travelling salesman problem, which made it difficult for humans to discover or be confident of the solution. Expert systems consist of the following,(Barr,Feignbaum and Cohen, 1981):

1. Facts about the domain (Knowledge base).

2. Rules or procedures.

3. Heuristics or what might be good things to try.

4. Global strategies.

5. A "theory" of the domain.

1.1.3.2.1 SCIENCE AI APPLICATIONS -

AI applications have dealt with areas of chemistry, mathematics, geology and other science disciplines. The following is a brief description of AI works in chemistry, mathematics and geology.

1.1.3.2.1.1 CHEMISTRY APPLICATIONS -

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Traditionally most computer programs in the area of chemical analysis have focused on numeric problems of data acquisition, data reduction and computer caluclations. AI on the other hand concentrates on chemical reasoning problems:

1. Determining the structure of complex chemical compounds.

2. Synthesizing new chemical compounds.

The Heuristic DENDRAL program based on DENDRAL algorithm and the CONGEN program which removed some of the limitations of chemical structures are but two examples of AI applications in chemistry, (Buchanan, 1969). These programs have produced a number of results of significance to chemists.

1.1.3.2.1.2 MATHEMATICS APPLICATIONS -

AI research has been active in finding ways to help mathematicians and scientists solve mathematical problems. Most of the research has gone into symbol manipulating programs such as MACSYMA developed at MIT. The original design was made by Engleman, Martin and Moses (1968). It uses symbolic inputs and yields symbolic results. It performs over 600 distinct mathematical operations, including, integration, differentiation, solution of differential equations, Taylor series expansions, matrix manipulation and vector algebra.

1.1.3.2.1.3 GEOLOGY APPLICATIONS -

Stanford Research Institute International has done research on computer based consultant systems (CBC). The system uses expert systems techniques to build a knowledge base on subject domain. PROSPECTOR is a computer consulting program which helps experts solve geology or mining related problems. In this domain, the knowledge base model is a description of the most important types of ore deposits and surface geological observations. The user provides PROSPECTOR with the most significant features of his/her prospect, such as rock types, minerals, and alteration products.

The program matches these observations against its models and, when the user has finished volunteering information, proceeds to ask the users for additional information that will help confirm the best matching model. The user during a consultation, may interrupt to volunteer new information, modify previous statements or request an evaluation.

1.1.3.2.2 APPLICATIONS RESEARCH IN MEDICINE -

INTRODUCTION

The main objective of AI research in medicine is to aid in disease diagnostics. Expert systems techniques are used in developing expert computer based medical consultation systems. Researchers interested in this subject are motivated first by the obvious benefits to society from providing reliable diagnostic services at a reduced cost. This is due to the observation (Ledley and Lusted, 1959) that most of the errors committed by clinicians are errors of omission i.e. the diagnostician does not consider all possibilities. Given adequate patient data, a computer program can be designed to exhaust all possibilities of disease knowledge base in the medical domain. Computers can also calculate doses of medicine much faster and more accurately than humans. Computers can also prescribe antibiotic dosages much better than do physicians.

The second reason for research motivation of the subject is found in computer science itself. Clinical medicine has been a good area for the study of cognitive processes. Diagnosis as a cognitive process has been studied extensively (Jacques, 1964). It involves highly developed medical taxonomy, large knowledge base, and experienced experts in the domain with superior performance. Also the problem solving found in the domain is repetitive which makes it more interesting for investigation. Applications such as these put AI research of "knowledge engineering" as real worthwhile techniques to confront worthwhile real world problems.

Several AI medical applications programs were developed one example is MYCIN system (Shortliffe, 1976) which was designed to provide consultation on diagnosis of infectious disease. MYCIN interviews the doctor about the patient condition, collecting information from which it infers the diagnosis and selects an appropriate therapy.

1.1.3.2.3 AUTOMATIC PROGRAMMING APPLICATIONS (AP) -

Programming can be defined as the process of specifying for the computer what to do. The simplest form of machine programming is coding an algorithm in terms of its primitives of addition, multiplication, subtraction and division. The introduction of compilers, program primitives and code, brought programming closer to the human level. The development of compilers was the first step towards (AP). The first FORTRAN compiler was called "automatic programming ", (Backus, 1958). At the practical level AP objective is to help programmers to write programs. Some contend that AP will spare programmers the chore of programming (Biermann, 1976). Others contend that AP helps the programmer do part of the programming task. Yet another view of AP states that the computer writes its own programs (Heidron, 1977).

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Automatic programming research in any case refers to assisting programmers to develop programs. All of these systems can be characterized by: a specification, a target language, a problem area and an approach.

Specifications are done through the use of higher level languages such as COBOL or FORTRAN. The syntax and semantics of these specifications are fixed and unambiguous. Other specification methods are by "example" in which enough examples are given so that the AP system can construct the required program. Natural language such as English is also used as a means of program specifications. This method is usually interactive.

Target language such as LISP or GPSS would be fed examples and then are expected to produce a program written in LISP or GPSS. The examples here serve as the means of telling the program what we want it to do and from which the AP system would produce the final program.

The problem area is another characteristic of AP systems. An AP system covers a certain scope of the application area such as payroll, personnel, invertory control and so on. This influences the AP system approach of producing the final program.

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The method of operation indicates the approach taken by the AP system. This could be theorem proving, program transformation, knowledge engineering or traditional problem solving.

An example of AP is the PSI system of AP develped by Cordell Green at Stanford University. The system deals with programs in the general class of symbolic computation of list proccessing, searching and sorting, data storage and retrieval and concept formation. It is composed of a set of knowledge base routines that perform all these symblic computation functions.

1.1.3.2.4 EDUCATION -

The goal of computer applications in education is the use of the computer to interact directly with the student or learner, rather than to assist the teacher. Scientists have used three approaches in their efforts to try to reach the stated objective.

The first approach allowed the student a "free-style" use of the computer, (Abelson and diSessa, 1981). Learning, it is conjectured, takes place as a side effect of programming the computer. Students employ languages that are fairly simple to use like "LOGO" to program subject matter problems and in the process learn the subject material, problem solving techniques, and general strategies. The second approach relies upon computer simulations as instructional media. The student interacts with the computer to perform experiments. The simulation could be for example that of Ohm's Law of electricity, Boyle's Law of gases, models of population growth or any process that can be modeled and simulated. Learning in this case is the side effect knowledge or experience gained through conducting such simulated experiments using a computer. The third approach of computer applications in education is the use of computer assisted instruction, (CAI) or computer based instruction, (CBI). The terms CAI and CBI are used interchangeably, the difference between them is very subtle. The CAI approach, unlike the first two, has the objective of controlling the learning process, (Howe, 1973). It is in this area, CAI, that the application of AI research is concentrated. An example of such an application is the WHY tutoring system, (Steven, Collins, Golden, 1978). The WHY system is an intelligent computer assisted instructions system ICAI which uses Socratic tutoring heuristics, (see Review Of the Literature Chapter for detailed description of ICAI systems that have been developed and tested).

Computer Assisted Instructions (CAI) techniques have been around for sometime. Though, they have made impact, they have not been satisfactory. Effective instruction requires that a student learns what is taught. Human instructors are extremely skilful and there is little evidence that existing CAI Systems out-perform them in transfering knowledge and skills to students. There are three main reasons for this situation. First, the human teacher has knowledge of individual students that can be refined and built on. He maintains an internal model of what a student knows. CAI systems may record what training a student has received, but this is not the same as having an idea of what the student knows. Second, human teachers understand the subject they are teaching. They are able to answer questions about the subject and solve problems in the subject domain. Conventional CAI systems do not have real subject understanding. Third, analysis of teacher student interactions reveals that a mixed initiative dialogue occurs, that is, a dialogue in which the teacher or student at any moment has the initiative or control. CAI, on the other hand, is generally more authoritarian in approach, relegating the student to a passive role of answering questions.

1.1.4 CONTENTS

This chapter (Chapter I) presented the statment and the scope of the problem under study. It also outlined the background needed to carry out this research. Chapter two contains a review of ICAI systems that have been developed and tested in Western cultures. Methodology is presented in chapter three where limitations, assumptions, research instruments and procedures are discussed. Findings are presented in chapter four and interpretations and significance are discussed in chapter five.

CHAPTER 2

REVIEW OF LITERATURE

2.1 REVIEW OF LITERATURE

Researchers have been looking into ways of using the computer as an instructional tool. When investigating computer applications in education one must look at various models of learning, computer based instruction, psychology of learning and the theory from which these models are derived.

There are two areas one must examine when dealing with the applications of the computer in education. The first covers the processes of learning and learning psychology which are based in cognitive science, and the second covers computer based instructions techniques which are based in computer science.

2.1.1 LEARNING

The question that we must ask when using the computer as an instructional tool is, can students learn from the computer? Put in another way, can the computer teach very much like a "teacher"? In a way we are saying can the computer replace the teacher? To answer these questions we must look at the process of learning and the relationship between teacher and student.

Wilson, (1978) assumes that there is a traditional student-teacher relationship or interaction in his discussion of the pedagogy of learning. This traditional interaction is based on the lecture method of instruction. The teacher "fills the student's bucket" with the required verbal knowledge. Wilson also suggests that teachers and administrators "modify and innovate where appropriate". This does not mean an unplanned or random approach to education. However many of the problems of education are caused by a strict application of the lecture method and reliance on verbal information. If the pedagogical methodology stresses knowledge alone, the amount of learning that occurs is less than optimal. Students must learn to synthesize, analyze and evaluate. It is not enough to learn only the knowledge.

The word "Pedagogy" is derived from the Greek. It means "Child leading". College students are no longer children to be lead. Therefore models based on pedagogy may be inappropriate for those disciplines that require problem-solving abilities with abilities to synthesize, analyze and evaluate. Because university students are more like adults they should be working at the formal operational levels (Piaget, 1981; Fischer, 1982). Such students have different developmental characteristics, cognitive goals, and information processing styles than pre-adolescents.

Vygotsky (1978) states that the learner must play an active part in the learning process if we desire an effective and efficient educational system. Empirical observation by Piaget (1970) and Fischer (1980) confirms the desirability of active learning. The literature of management and human organizational behavior (Hertzberg, 1966; Maslow, 1970; Porter and Lawler, 1968 ; Vroom, 1964) states that people play an active role in determining their level of motivation.

Since Schools and school systems are human organizations, each "player" in the educational "game" has a role, or several simultaneous roles to play. These roles form a set of expected behaviors and mechanisms for dealing with maintenance and motivation factors that relate to the achievement of educational objectives.

Owens, (1981) believes that expectancy theory (Vroom, 1964; Porter and Lawler, 1968) explains that the effort one puts into work depends upon:

1. The value an individual places on the expected intrinsic and extrinsic rewards.

2. The likelihood that the reward actually will be received if the effort to reach the goal is made.

If this is true, and research already cited indicates that it is, then individual students must possess:

1. The necessary abilities and traits.

2. An accurate perception of the student's role to back up the effort and to produce intended educational outcomes.

Since university students are more like adults than children there are many differences in human information processing style and learning style that must be considered when we prepare a computer program for teaching and learning. Lippitt, (1983) confirms that learning is a different process for children and adults. This study establishes the following characteristics of adult learning for our purposes of the computer applications of AI to education:

1. Adults learn what they feel a need to learn.

2. Adults learn best by doing.

3. Adults want to know how well they are doing and why (feedback).

4. Adults learn best through problem solving.

5. Adults prefer an information learning environment.

These conditions are consistent with goal directed and consequent educational achievement oriented behavior. They are also compatible with an intrinsic motivation paradigm.

But one may ask just how does the use of CAI programs help students achieve their goals?. The answer to this question as established by the literature is that the computer helps students achieve their educational goals by requiring active participation in the learning process. Self directed learning activities using "intelligent" computers can be an integral part of the adult education model, (Liao, 1978). The student interaction with the "intelligent" computer and resultant self directed learning lead to increased achievement.

Interactions with the computer should be self directed. People who use computers know that the individual must take an active role in "working" with the machine. It is also significant that the student may elect when to interact and when to learn. Students are also able to select, at their option, the time and duration of lessons. This flexibility of self directed learning is the core of the adult model of teaching/learning.

2.1.2 APPLICATIONS OF ARTIFICIAL INTELLIGENCE RESEARCH IN EDUCATION

Applications of the computer in education have been under development since 1960. Computers are used to process admissions, student registration, grading tests and as a teaching aid. The main application however has been in using the computer to interact directly with the student, not as a teacher assistant. Scientists have used mainly three approaches in the development of computer applications to the learning process.

Learning as a side effect of programming the computer to solve problems is called the "ad-lib" approach which has been typified by Seymour Papert's "LOGO" laboratory. This model of learning allows the student a "free-use" of the machine. This method, it is conjectured, enables the student to learn as a result of or a "by-product" of working with tools that are designed to suggest good problem-solving strategies to the student.

The second approach to developing computer applications instructional tools uses games and simulations. An interactive learning environment is created in which the student is allowed to role-play with the view to experiment with different courses of action in particular circumstances, then examining outcomes of such actions. Generally speaking, simulations are done through the use of modules which approximate reality, (Payne, Hutchings, and Ayre, 1980). Proponents of the simulation approach to learning contend it to be a powerful motivator of learning.

The third approach and the one which draws the attention of researchers the most, is the Computer Assisted Instructions Technique. This model attempts to control the learning process, (Howe,1973). The computer is programmed to attempt, generally at an educationally routine level and for a short period of time, to take over a role which might otherwise be played by a tutor. The computer "asks" questions which students attempt to answer by entering a response directly into the computer. The student gets immediate "feedback".

The goal of CAI is to produce instructional tools (Computer Programs) that incorporate well prepared course material in lessons that are optimised for each learner. CAI programs have been traditionally either electronic "frame-turners", which displayed prepared text, or drill and practice monitors, which displayed questions and responded to students answers using prestored answers and remedies.

Since the early seventies, researchers have been trying to find more effective, more "intelligent" ways of preparing course materials. This is also the area where this research is conducting this investigation to establish the effectiveness of intelligent applications of CAI.

Applications of AI techniques to make Intelligent Computer Assisted Instructions (CAI) programs have been developed to represent the course material independently of teaching procedures. This way problems and remedial comments could be tailored to each student's needs. ICAI programs are sensitive to a student's strength, weaknesses and prefered learning style and are the subject of review in this chapter.

2.1.2.1 INTELLIGENT CAI SYSTEMS (ICAI) -

There are several ICAI systems that were developed and tested since the early seventies. Research is continuing in this area. Applications of AI to CAI are the computer technology in education, the focus of the ICAI systems described in this chapter.

The early CAI instructional applications of the computer adhered to essentially the same pedagogical philosophy. The learner was given instructions and asked questions that require brief answers usually online. The student was then told if his/her answer was right or wrong. The answers given by a student sometimes determined a "path" through a given curriculum. In other words the sequence of problems presented to him will vary depending on his responses to the given questions, (Atkinson and Wilson, 1969; Barr and Atkinson, 1977). The program branched to remedial material depending on the error a student made. The author of a given CAI course attempts to anticipate every wrong response, and builds into it branches to remedial material which he/she conceives what might cause a wrong response. The objective of branching on the basis of response is the individualization of instructions, (Crowder, 1962). This style of CAI has been called "ad-hoc", frame-oriented (AFO) CAI by Carbonell (1970) to stress its dependence on author-specified units of information. The Skinnerian stimulus-response principles were used in the design of "ad-hoc" frames. "Steering" the student through a curriculum and the strategies used in some "ad-hoc" frame-oriented programs have become so complex and incorporated learning theory of mathematical psychology. Some of these systems are available commercially and have been used successfully.

It seems even with the wide spread use of AFO programs and their relative success, many researchers reject them as the best use of computer technology in education:

"In most CAI systems of the AFO type, the computer does little more than what a programmed textbook can do, and one may wonder why the machine is used at all... when teaching sequences are extremely simple, perhaps trivial, one should consider doing away with the computer, and using other devices or techniques more related to the task." (Carbonell, 1970b)

Carbonell defines a second type of CAI which is described today as knowledge-based or Intelligent CAI. Both types of systems CAI and ICAI represent within them the subject matter they teach, but ICAI systems are distinguished by the technique of carrying on a dialogue with the student and use the student's mistakes to diagnose his misconceptions.

The first uses of AI techniques in CAI stressed problem generation from a large data base which represented the subject matter, (Koffman and Blount,1975). Carbonell, However, described what was to be more than just a problem generator. It was to be a computer tutor that has the inductive and reasoning power of its human counterpart. In other words it was to have the qualities of a human "teacher". Brown, (1977) envisioned an ICAI program which he calls "reactive learning environment", in which the student is actively envolved with the instructional systems and the tutorial dialogue is driven by the student's interests and misconcptions. This goal was stated by other researchers trying to write CAI programs that extend the teaching medium beyond the limits of frame or page turning:

" Often it is not sufficient to tell a student he is wrong and indicate the correct solution method. An intelligent CAI system should be able to make hypothesis based on a student's error history as to where the real source of his difficulty lies", (Koffman and Blount, 1975).

AI work in natural-language understanding, knowledge representation and methods of inference have been applied by researchers in making CAI programs more intelligent and effective. Benchmark efforts include SOPHIE, the electronic troubleshooting tutor of Brown and Burton, SCHOLAR, the geography tutor of Carbonnel and Collins and other tutors described in this chapter. ICAI programs are different from the most sophisticated CAI programs:

" The traditional approaches to this problem using decision theory and scholastic learning models have reached a dead end due to their oversimplified representation of learning ... It appears within reach of AI mehtodology to develop CAI systems that act more like human teachers." (Laubsch, 1975).

However a good teacher must know what the student is doing not just what he/she is supposed to do. Some AI programs do employ sometimes very powerful problem-solving methods that do not resemble those of humans. CAI researchers have used techniques of representing the subject domain expertise which made the inference procedures less powerful in order to make them follow human reasoning patterns and to make the line of reasoning more understandable to the student and to model his/her problem-solving more closely, (Goldberg, 1973; Smith 1976). A second phase in the development of ICAI systems, in the mid 1970s, was characterized by the inclusion of additional expertise in the systems regarding the students' learning behavior and by the tutoring strategies used (Brown and Goldstein, 1977). AI techniques modeled the learner by representing his knowledge in terms of skills that are to be learned, (Barr and Atkinson, 1977). Some ICAI programs, of which some are described here, are now using AI techniques that represent explicitly those strategies.

2.1.2.2 ICAI SYSTEMS DESIGN -

Researchers design ICAI systems using the following main components:

1. Problem-solving expertise or the knowledge presented to the student.

2. A student model or the level of knowledge the student has reached. What he/ she knows.

3. Tutoring strategies or the method of information presentation to the student? (Self, 1974).

ICAI systems do not concentrate on the incorporation of all these components in their design. Researchers have encountered some difficulties because of complexity and size.

2.1.2.2.1 EXPERTISE MODULE -

The task of the expert module of an ICAI is to generate problems and to evaluate correctness of the student solution. ICAI systems perform these tasks by employing procedural representation of domain knowledge and taking measurements and making deductions. Knowledge is represented as procedural experts of subskills which the student must learn in order to acquire the complete skill being taught, (Brown, Burton and Bell, 1974). Production rules (an AI technique of knowledge representation) have been employed in the construction of modular representation skills and problem solving methods, (Goldstein, 1977; Clancey, 1979). "Problem-solving grammers" have been used as representation of expertise of writing computer programs, (Miller and Goldstein, 1977). "Multiple representations" have also been employed and are useful for answering student questions and evaluating solutions to a problem, (Brown and Burton, 1978).

An example is a semantic net of facts about a computer program and associated procedures simulating the functional behavior of the program. Multiple simulations of a series of models for reasoning about the behavior of causal systems was employed by Stevens and Collins, (1978a).

Some ICAI systems do not employ procedures for solving every problem they pose to the student. An example is the SOPHIE research described elsewhere in this chapter. Others, like WUMPUS and GUIDON solve problems independently by employing production-rules representation of the domain knowledge. The ability to solve problems, in any of several ways is necessary if the ICAI program is to make accurate suggestions about the completion of partial solutions, (Barr and Feigenbaum, and Cohen, 1981).

ICAI systems incorporate "articulate" experts that can explain each problem-solving decision which resembles that of a human problem-solver, (Goldstein, 1977). Others like SOPHIE-I do not mimic human problem-solving techniques and are "transparent" or "opaque" to the user. WEST (described in this chapter) is an example of an "articulate" expert. ICAI systems are distinguished by separating "teach" strategies from subject matter. This requires a structure for capturing the difficulty of problems and inter relationships of course material. Trees have been used as a structure for showing interactions used to organize new knowledge BIP (see this chapter) employed trees to represent "curriculum net" that related the skills to be taught to sample programming tasks which tested each skill (Barr, Beard, and Atkinson, 1976). In WUMPUS research (Goldstein, 1979) used trees to represent the path a learner takes in acquiring new skills. Curriculum units called "issues" were employed by Brown and Burton (1978) to excercise arithmetic skills in WEST. These "issues" used arithmetic operations and strategies at different levels for improving performance. Burton and Brown state that when skills are "structurally independent" their order of presentation is not crucial and is useful in modeling a students knowledge. Stevens, Collins and Goldin (1978) contend that a good human tutor does not go through a predetermined network of knowledge for material to present, rather he capitalizes on the misconception of the student in order to produce a learning dialogue.

2.1.2.2.2 THE STUDENT MODEL -

ICAI systems model the state of understanding of the material to be taught to the student. The model makes assumptions about the student's misconception and suboptimal performance. Thus it can suggest corrections, point out weaknesses, and reasons why they are wrong. The system should also be able to have alternative problem solutions. The state of understanding of the material by the student is modeled using a variety of AI techniques of modeling the student knowledge.

Student knowledge may be modeled by simple pattern recognition derived for student response history and recording in the rule knowledge base of the subject matter that the student has mastered. ICAI systems form a student model by comparing his/her behavior to that of the computer based "expert" in the same environment. An indication of the evidence of a student's knowledge of material is marked by the modeling component, This is known as overlay model, (Carr and Goldstein, 1977).

Another way to model student knowledge is to consider the student knowledge as "deviation" or "bug" from the expert's knowledge. The SOPHIE and BUGGY systems are examples of this technique, (see this chapter). It is assumed here that the student reasoning is different from that of the "expert". Goldstein, (1977) states that information as evidence of a student's model is collected and characterized from:

1. The student problem-solving behavior, "implicit" to the student model.

2. The questions asked of the student, "explicit" to the student model.

3. The student's experience or "historical" record.

4. Assumptions about the difficulty of the subject matter.

A main difficulty encountered by ICAI programs in inferring "implicit" information from the student's problem-solving behavior is the limited ability of the program to know the strategies applied by the student. When a student's behavoir is wrong at the presentation of the expert of a chain of inference, the program is unable to know which steps are wrongly applied by the student. Goldstein (1977) points out that the student modeling process attempts to measure the student learning and to decide which teaching methods are effective. Demonstration of extreme behaviors of the expertise of problem solving might indicate that the representation in the model does not capture the student's approach. Considerable research is needed on this issue.

2.1.2.2.3 TUTORING MODULE -

This module integrates knowledge of the subject area, the teaching methods and the natural-language dialogues. It has the fallowing functions:

1. Communicates with the student.

2. Selects problems to solve.

3. Monitors and criticizes his/her performance.

4. Provides assistance when requested.

5. Selects and provides remedial information.

Tutoring requires teaching skills which require knowledge beyond the mastery of the subject domain, (Brown, 1977). It is knowledge of how to teach. Most ICAI research has investigated teaching methods of "diagnostic modeling". This method evaluates the student's understanding derived from his response, (Collins,1976; Brown and Burton, 1978; Koffman and Blount, 1975). The program's "feedback" mechanism is used by the student to learn which skills he/she uses wrongly, properly and not at all. A More recent trend has been to tell the student the right thing and then let him/her realize his/ her own error and hence switch to a better method, (Carr and Goldstein, 1977; Brown, and Burton 1978; Norman, Gentner, and Stevens, 1976). This new approach concentrates on pointing out the "bug" or error made by the student and also gives enough information to him/her to focus on the deviation and analyze it so as to avoid and learn from his/her error.

Another method that ICAI systems are using, is to let the student debug his/her own error by providing him/her explicit debugging strategies. Written debugging strategies are provided to the student and then an experiment is conducted to detect more rational approach. Brown, Collins, and Harris (1978) suggest an interactive approach in which explicit strategies are given to the student then a test is conducted to detect improvement, then the process is repeated every time around modifying the student approach or strategy until he/she has shown optimal strategy.

"Coaching" is another teaching method which has been implemented by some ICAI systems, (Goldstein, 1977). This method encourages the student by "engaging" him /her in some activity such as a computer game. The immediate objective is to entertain the student while involved in the process of coaching and learning as an indirect consequence. The computer observes, interupts, suggests new strategies and offers new information to the studnet. The intelligent computer coaching program is able to know what knowledge and skill the student might acquire from observing his/her style and provide effective ways to "intercede" in the game to offer the proper advice.

Another teaching method that has been used by ICAI systems is the "Socratic method". The student is encouraged to reason about what he/she knows by engaging him/her in a dialogue based on real world interactions between student and teacher. The Socratic approach questions the student repetitively requiring the student to persue a certain line of reasoning. All interactive "mixed-initiative" tutoring depends on some dialogue, but some are "intrusive" like the Socratic approach and some "non-intrusive" such as the coaching approach. Collins (1976) has investigated and described teaching strategies. More recent ICAI application research has explored the representation of these teaching strategies as "Production-rules". These tutoring rules are arranged into procedures to cope with various situations in the tutorial dialague. Some of the functions of these procedures are introducing new topics, examining students misconceptions, relating inferences, planning the next strategy after the completion of a subproblem and summerizing a session.

2.1.3 ICAI Research

2.1.3.1 SCHOLAR -

SCHOLAR is a "mixed-initiative" computer based tutoring system. It is built with the following specifications:

1. It takes the initiative by generating tutorial questions.
2. Determines the students level of knowledge of the problem domain.

3. Identifies the student's misconceptions.

4. Able to deal with unanticipated student questions.

5. Able to generate instructional material at various levels of detail.

6. Able to communicate using English sentences.

SCHOLAR has been developed by Carbonell and Collins to tutor students in South American geography. The knowledge representation and tutoring strategies used are applicable to other domains of knowledge. The objective of SCHOLAR is to investigate the nature of tutorial dialogues and human reasoning. The research explores the following AI questions:

1. How can knowledge be represented for fact storage/retrieval of facts needed in a tutoring environment?

2. What strategies are necessary to make inferences from the typically incomplete data base of the tutoring program.

3. How strategies can be separated or made independent of the knowledge representation in the tutor program.

2.1.3.1.1 KNOWLEDGE REPRESENTATION -

Domain knowledge is represented in SCHOLAR database to be presented for tutoring in a "semantic net". Semantic nets are a systematic way of knowledge representation described by Winston, (1981). Each unit in the semantic net corresponds to a geographical division or object and is composed of the geographical name and a set of properties describing the geographical object. The properties are lists of pairs of attributes and corresponding values. Attributes are units that are defined in the net. An example would be "rock" and "rock" refers to topography. Values can be Locations such as Eastern. SCHOLAR uses special attributes such as SUPERA for superattribute, SUPERC for superconcept, SUPERP for superpart. An example of SUPERC is the fact that Chile is a country; and of SUPERP, that Chile is in South America.

2.1.3.1.2 TUTORIAL DIALOGUE -

SCHOLAR uses the Socratic method of tutoring. It captures the student's misconceptions, performs diagnosis of the misconceptions and then presents material that will make the student see his/her own errors. The SCHOLAR research used human tutorial protocols, analyzed them to synthesize the strategies people follow and then attempted to use these protocols and strategies into the system. An excerpt of the South American geography tutor follows:

SCHOLAR: What is the language of Argentina?

Student: Probably Spanish

SCHOLAR: Very good. Approximately what is the area of Argentina (The student does not answer but rather changes topic)

STUDENT: Tell me something about Peru?

SCHOLAR: Peru is a country. It is located in South America. The Capital of Peru is Lima. Now answer the question you did not answer.

STUDENT: The area of Argentina is 1,000,000 square miles.

SCHOLAR: Approximately true, but a more exact value is 1,200,000. The eastern bordering country of Peru is ....

STUDENT: Catholicism

SCHOLAR: Wrong. Catholicism is not a country but a religion. The correct answer is :Brazil.
Where is Peru? (The student changes the subject again)

STUDENT: Is Asuncion hot?

SCHOLAR: Since Asuncion is part of paraguay, yes.

STUDENT: What is the most important differnce between Peru and Paraguay?

SCHOLAR: The primary difference is: The population of Peru is larger by a factor of 7.8.

SCHOLAR uses a "case grammer system", (Barr,Feigenbaum and Cohen, 1981) and the semantic interpretation of a students' response is heavily guided by the geography knowledge in the semantic net. Natural language processing in SCHOLAR is important and allows the student to take initiative and ask questions that were not anticipated by the program. Case grammer is also used to construct new questions and answers from the semantic network.

2.1.3.1.3 INFERENCE STRATEGY -

SCHOLAR inference strategy of evaluating answers to a student's questions is designed to deal with the incompleteness of the semantic-net knowledge base. Important strategies dealing with the incompleteness issue are:

1. Intersection search.

2. Common superordinate.

3. Open and closed sets.

Intersection search: This search answers questions of the type "can X be part of Y?" (e.g. "is Buenos Aires in Argentina?"). The search is carried out as the superpart (SUPERP) arcs of both nodes for X and Y are traced until an intersection is found, which means until a superconcept node is found. If there is no intersection the answer is "No." If there is an intersection node say Q, SCHOLAR answers with the following:

If Q = Y, then "yes";

If Q = X, then "NO, Y is an X".

The question "Is Buenos Aires in Argentina?" "is answered "Yes" since Argentina is SUPERP of Buenos Aires in the net (Q = Y):

Soth America ---> Argentina (Y) ---> Buenos Aires (X)

(SUPERPART) (SUPERPART)

The question "Is Argentina in Buenos Aires?", Is answered "No, Buenos Aires is in Argentina".

Common superordinate: If the common supernode Q, is not equal to X or Y, the program examines if X and Y have mutually exclusive properties. If that were the case the answer is "No"; else the answer is "I do not know". Questions like "Is X a Y ?" are answered similarly except SUPERC superconcept are used for the intersection search.

Open and closed sets: In SCHOLAR's net, sets are tagged by courseware author as either "open" or "closed". This gives an indication of the incompleteness of the system's knowledge. This means that when a question such as (" How many cities in Columbia are on the Atlantic?") a distinction is made about whether the resulting set of these objects (Cities on the Atlantic) is closed or explicitly contains all such objects or units. SCHOLAR can answer closed set questions easily such as "Is France a country in South

America?". The closed set here is the countries of South America. Similar questions about open sets is more difficult to answer and require the use of special techniques. If we ask the question "Is rubber a product of Guyana?" and there is no explicit information about the production of rubber in Guyana in the net then SCHOLAR starts to reason with what knowledge it has "It compares the importance tags of the agricultural products of Guyana with the importance tags for rubber in countries that it knows produce rubber. It knows Peru is a rubber producer therefore it compares its importance tag to the least important importance tag of Gyuana, if it compares SCHOLAR assumes that it knows about Guyana as much (up to the importrance tag value) as it knows about Peru. Therefore, SCHOLAR infers that it knows about rubber production in Guyana if it were important. Since rubber is not listed for Guyana, SCHOLAR makes the plausible, (not certain) conclusion that rubber is not produced in Guyana. At this point SCHOLAR answers that it does not know and gives the information about rubber production in Peru." This use of knowledge about the extent of its knowledge in this "plausible reasoning ", (Collins, 1978b) is unique in AI research.

2.1.3.2 WHY SYSTEM -

REVIEW OF LITERATURE

Stevens and Collins (1978) describe a system called WHY, that tutors students in the causes of rainfall, a complete geographical process which is a function of many related factors. In their research on tutorial dialogue employed by WHY, the research group (Stevens, Collins and Goldin, 1978) has focused on these questions that are central themes throughout ICAI research:

1. What is the "goal structure " of a Socratic tutor?

2. How do tutors diagnose student miscomceptions from the errors they make?

3. What are the abstractions, view points that tutors use to explain physical processes?

Collins and Stevens identified a theory of tutoring from the analysis of tutorial dialogues between human experts and students. These are incorporated into a tutorial program which is then tested to find the weak points of the theory for further investigation. The WHY system is the first of such iterations and concentrates on the Socratic approach of teaching.

Socratic tutoring uses heuristics to model explicitly the nature of the Socratic dialogue in the current version of WHY. Twenty four heuristics control the student/system interaction. A sample heuristic is:

If   The student gives as an explanation of causal dependence one or more factors that are not neccessary,

Then select a counter example with the wrong value of the factor and ask the student why his causal dependence does not hold in that case.

The student is forced to consider the necessity of a particular factor. An illustration would be, if the student gives rainfall as a reason for growing rice, then the computer-generated counterexample "why do they grow rice in Egypt where there isn't much rainfall?" challanges the student's explanation of rice growing. These heuristics facilitate the tutorial dialogues in which the student is forced to consider combinations of factors and generalize from specific facts or cases to general conditions or principles,(Collins, 1976).

WHY represents knowledge in a "script-like" data structures, which takes advantage of the temporal relations in the rainfall process, for example, first, water evaporates from an ocean or sea, then the water-laden air mass is carried over land by winds, which in turn causes the air mass to cool, which causes precipitation. This representation is adequate for capturing the characteristics of a tutorial dialogue, but there are other kinds of knowledge about rain, not represented and are discussed below.

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The following is part of a dialogue of the current version of the WHY system The student is prompted for the causes of rainfall and for prior or intermediate causes and to suggest a general rule. When the student suggests a rule the system finds a counterexample and forces revision of the rule and the process is iterated until a rule of sufficient generality is found.

WHY : Do you think the Amazon jungle has heavy rainfall or light rainfall?

STUDENT: Heavy rainfall.

WHY : Why does the Amazon jungle have heavy rainfall?

STUDENT: Because it is near the Atlantic

WHY : Yes, the Amazon jungle is near the equatorial Atlantic. How does that affect rainfall in the Amazon jungle?

STUDENT: The water in the current is warm

WHY : What happens after the moisture-filled air reaches the land?

STUDENT: I do not know.

WHY : Do you think the Andes mountains range has any effect on the rainfall in the Amazon jungle?

STUDENT: Yes.

WHY : How ?

STUDENT: The prevailing wind hits the Andes and the air cools.

WHY : How does the fact that the prevailing wind hits the

Andes lead to air cooling? Do you think that any place with mountains has heavy rainfall?

STUDETN: Yes

WHY : Southern California has mountains. Why doesn't Southern California have heavy rainfall?

Stevens and Collins(1978) have set two goals for the WHY system for carrying its tutorial dialogue.

The main goal is to identify and correct the students misconceptions. This involves five knids of bugs or errors:

1. Factual errors: The system (tutor) deals with factual errors by correcting the student, however the Socratic method deals with the interelations of facts.

2. Outside-domain Bugs: These are misconceptions about causal structure. The tutor does not explain the remedy in detail but concentrates on the relationships of the causal effects. An example is the relationship between the temperature of the air and its moisture holding capacity is stated as a fact and allows the student to realize his/her misconception.

3. Overgeneralization: Whenever a student makes a general rule or statement from insufficient data (e.g. Any place with mountains has heavy rainfall), the tutor will find counterexample to poke for more factors.

4. Overdifferentiation: This occurs when the student introduces a factor as necessary and the tutor finds a counterexample to suggest the contrary.

5. Reasoning Bugs: The tutor teaches the student skills in forming and testing hypotheses, then collecting data then drawing conclusions.

The WHY system also decides which bug to correct first in case the student displayed more than one misconception. It employs a set of heuristics to decide which one to correct first. This is important for carrying on with the dialogue. The tutor corrects errors before omissions, causal prior factors before later ones, short ones before long ones, and low level before high level ones in the network.

The temporal script representation in WHY did not solve all the student misconceptions, because it is domain dependent. Stevens, Collins and Goldin (1978), defined later "functional relationship" which represented student misconceptions as errors in the student's model of these relationships. A functional relationship has four components:

1. A set of actors each with a role in the process.

2. A set of factors that affect the process, all of which are attributes of the actors such as water is an actor in the evaporation relationship and its temperature is a factor.

3. The result of the process, which is a change in the attribute of one of the actors.

4. The relationship that holds between the actors and the result.

These functional relationships are representations of other domains and are used by analogy to the domain of the WHY tutor. More research is needed on knowledge representation for meeting the objectives of intelligent tutoring.

2.1.3.3 SOPHIE -

SOPHIE or Sophisticated Instructional Environment is an ICAI system developed with the following objectives. (Also see figure SOPHIE for model of SOPHIE)

1. Explore broader student initiative during the tutorial interaction.

2. Provide the student with an environment to acquire problem-solving skills by experimentation.

The (SOPHIE) system achieves these objectives by:

1. Using a model of problem solving in its domain.

2. Employing many heuristic strategies for answering questions, criticizing hypotheses, and suggesting alternative theories.

3. Allowing a one to one relationship with a computer based "expert" that helps the student to come up with his/her own ideas, to try and debug these ideas.

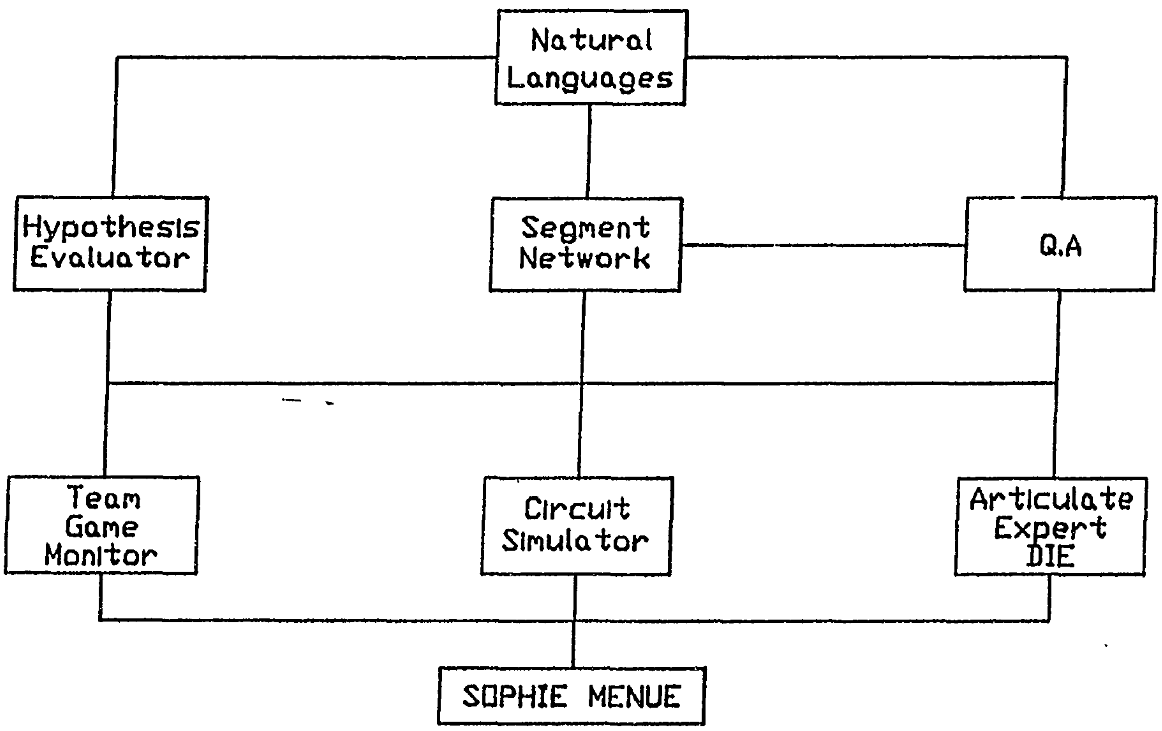

FIGURE SOPHIE
(Burton and Brown, 1979)

REVIEW OF LITERATURE

SOPHIE was designed to teach problem solving skills by simulating an electronics laboratory, (Brown and Burton, 1978). The problem for the student is to find the malfunctioning piece of equipment. He/she takes measurements such as voltages, currents and resistances, then makes assumptions and hypotheses about where the fault may be. These are tested by the system and if proved correct the fault is found), otherwise another hypothesis or more measurements are made and the process is repeated. SOPHIE helps the student by isolating faults and deciding if a measurement is valuable, based on whether it eliminates or isolates a fault. SOPHIE randomly selects a fault in the performance of a circuit component, inserts in a simulation of the circuit and tells the student how controls are set. The student is given a schematic diagram of the circuit and the dialogue refers to components in the schematic diagram which has the notation:

R8 = resistor 8;

N1 = node connection 1;

Q1 = transistor 1;

and so on.

The following is a sample protocol of SOPHIE (from Brown and Burton, 1978):

1. SOPHIE : Welcome to SOPHIE, a reactive learning environment. The piece of equipment you are studying is a regulated power supply. Would you

like to start with a faulted instrument that needs fixing.

2. STUDENT: Yes.

3. SOPHIE : The instrument has a fault and its present control settings are:

CC	1.0	CURRENT CONTROL.
CR	HIGH	CURRENT RANGE SWITCH.
LOAD	20	LOAD RESISTANCE IN OHMS.
VC	1.0	VOLTAGE CONTROL.
VR	HIGH	VOLTAGE RANGE SWITCH.

4. STUDENT: What is the output?

5. SOPHIE : The output voltage is 11.7 volts.

6. STUDENT: What is it in a working instrument?

7. SOPHIE : In a working circuit the output voltage is 9.9 volts.

8. STUDENT: WHAT is the voltage between R8 and Q1 ?

9. SOPHIE : The voltage at N1 is 47.6 volts.

10. STUDENT: Replace Q6.

11. SOPHIE : I am going to ask you some questions about how Q6 is faulted. Are any junctions shorted?

12. STUDENT: I do not know.

13. SOPHIE : Are any terminals open?

14. STUDENT: Yes.

15. SOPHIE : Which terminal(s) are open?

16. STUDENT: The base

17. SOPHIE : Q6 is not faulted in that manner. Q6 not replace (The student here learns that Q6 does not have an open base).

18. STUDENT: Is it possible that Q6 has open base?

19. SOPHIE : Is the complete fault mode EB/EC/BC= open LOK/open what you intended?

20. STUDENT: Sure.

21. SOPHIE : That fault is consistent with all of the measurements you have made.

2.1.3.3.1 SOPHIE's LANGUAGE INTERFACE -

SOPHIE uses a natural language interface based on semantic grammer. Nouns, verbs and adjectives are replaced by semantically meaningful concepts,(Brown and Burton, 1978). These concepts are known to the system such as measurements, circuit elements, transistors, hypotheses and so on. SOPHIE keeps a list of concepts and their corresponding grammer rules that represent the alternate ways of experessing those concepts in terms of their constituent concepts. Semantic grammer allows certain amount of "fuzziness" in its understanding of words presented of it. Thus if a student uses words or concepts that the system does not know, the parser of the grammer ignores these words/concepts and proceeds with the search to try to make sense of the sets of the words/concepts.

2.1.3.3.2 INFERENCING -

SOPHIE performs the following logical and tutorial tasks:

1. Answers hypothetical questions. (e.g. "if the base-emitter junction of the voltage-limitting transistor opens then what happens to the output voltage?").

2. Evaluates hypotheses: When a student presents SOPHIE with a hypothesis, it evaluates its consistency and identifies the information that supports or that is independent of the assertion.

3. Generates hypotheses: This involves constructing all possible hypotheses consistent with the known information. SOPHIE can answer questions such as "What could be wrong with the circuit given the measurements I

have taken?"

4. Determines redundancy: SOPHIE can determine if a certain measurement is not necessary because it could be determined from previous ones.

SOPHIE accomplishes these tasks by a simulation of the circuit under scrutiny. A changed voltage as a result of a modification to a circuit can be predicted by performing a simulation to the circuit and a table of voltages is produced. The answer is given in terms of the new generated voltages.

Experience with SOPHIE shows that its major weakness is its inability to follow up on errors. However the trouble shooting game played by SOPHIE has proven to be an effective way of training.

2.1.3.4 WEST -

The WEST system gets its name from a simulted board game "How the West was Won" and is the first research in computer coaching applications. The research is based on building a coaching computer model that monitors the student's work, occassionally making criticisms or suggestions for improvements, (Goldstein, 1977). The research objective in the work carried out by Brown and Burton, (1978) is to identitify, diagnostic strategies to pinpoint the student's misunderstanding from his/her observed behavior and explicit strategies for directing the student.

2.1.3.4.1 THEORY OF THE INSTRUCTIONAL COACH -

Computer-coaching research embodied in WEST is characterized as "guided discovery learning". It contends that the student constructs his/her own understanding of a given situation based on prior knowledge. According to this theory, the notion of misconception, or bug, plays a central role in the construction process. A bug in the student's knowledge will cause a suboptimal behavior and if the student has enough information to apply corrections, then the bug is constructive. If he/she does not have enough information then it is the role of the tutor to give the student enough extra information to determine the cause of the error, then apply corrections, thus turning non-constructive bugs to constructive ones, (Brown, and Burton, 1978).

WEST is a general paradigm of tutoring by "Issues and Examples". A coach's comments must be both relevant and memorable to the student. These two constraints are met by the use of the "Issues and Examples" tutoring strategy. "Issues" are concepts which identify what is relevant in the diagnostic process and "Examples" provide concrete instances of these abstract concepts. A generic Issue (a concept used to select a strategy) and a good Example of its use increases the chances that the student will incorporate this piece of commentary into his/her knowledge. In the "Issues and Examples" paradigm the Issues are the important concepts underlying a student's behavior, which the coach monitors.

2.1.3.4.2 HOW THE WEST MODEL WORKS -

The coaching process of WEST is shown in the model of Figure WEST When a student makes a move which is considered less than optimal by comparing his/her move to that of the expert module, the coach module uses the evaluation component of each Issue to create a list of Issues on which it has assessed that the student is weak. The coach then invokes the Issue recognizers component to determine a second list of Issues from the Expert's module list to create a new list of better moves. The coach module then selects an Issue and the move that illustrates it and decides whether or not to interrupt. If there are no Issues in common, the coach says nothing because the reason for the problem is outside the collection of Issues. If the coach module decides to interrupt then the Issue and Example are passed to the explanation generators which provide the feedback to the student. Explanations are represented in procedures called "Speakers" attached to each Issue. The Speaker presents the text for its Issue.

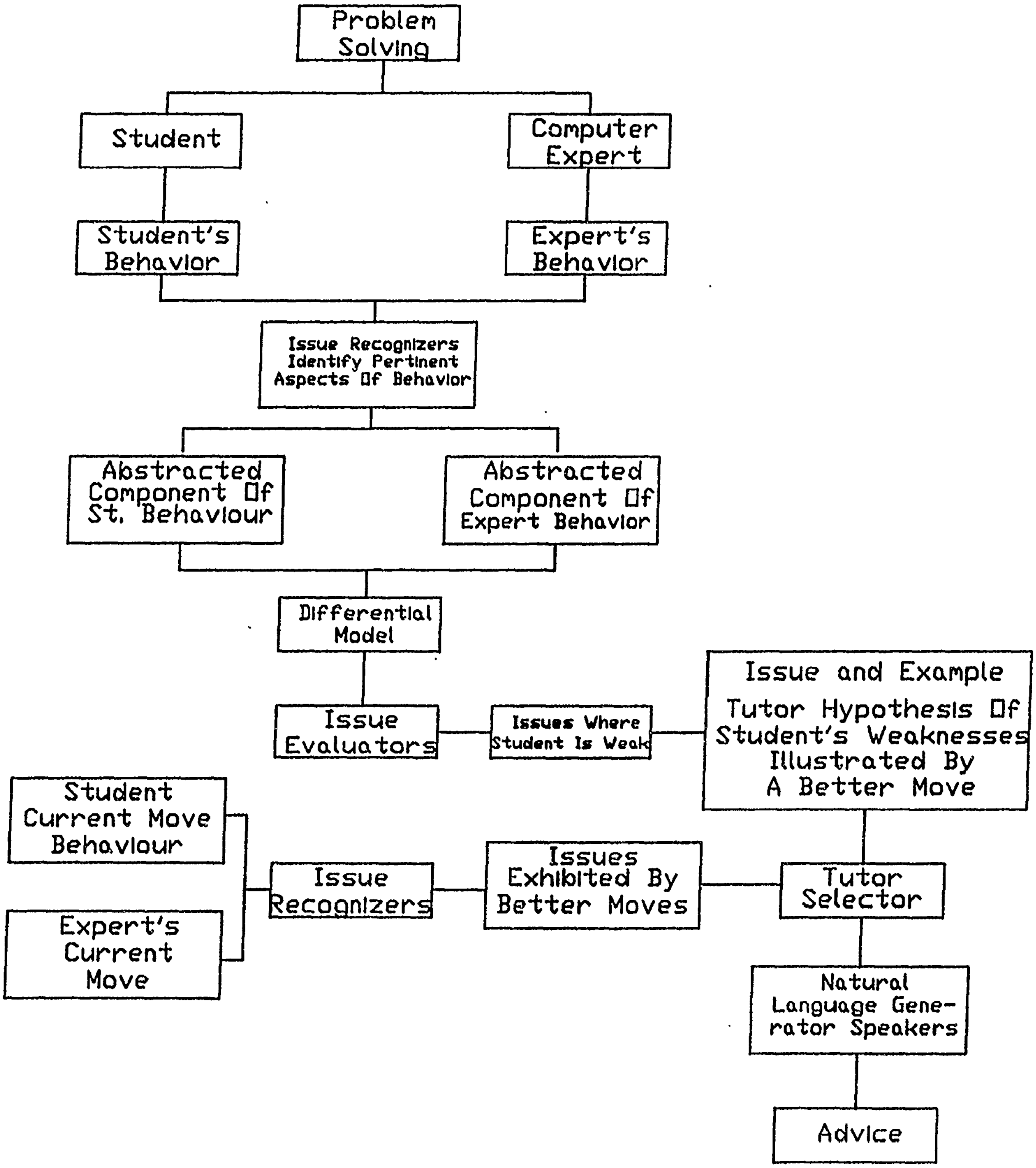

FIGURE WEST

Model Of The Coaching Process (Brown and Burton,1979)

REVIEW OF LITERATURE

The decision of the coach when to interrupt is made according to some tutoring principles. These principles dictate that, at times, even when relevant Issues and Examples have been identified, it may be inappropriate to interrupt. This happens when there are two competing Issues, both applicable to a certain situation. The question is then which one should be selected? The Issues in WEST are independent which means it is not necessary to examine their prerequisite structure. Additional tutoring principles are needed to decide which Issues should be used. The following principles guide WEST in this decision:

1. The focus strategy: Everything else being equal, the Issue most recently discussed is chosen. Concentrate on a particular Issue until evidence is present to indicate mastery of the Issue.

2. Breadth Strategy: Issues that have not been recently discussed get selected. This strategy is designed to keep the student from being bored.

3. Coaching Philosophy: The use of tutoring principles can enhance a student's likelihood of remembering what is said. An example of this is to use an Example when result would be superior to that of the student.

4. Maintaining Interest: The coach must not interrupt too often so as to cause the student to lose interest. Never tutor on two consecutive moves and congratulate the student for making exceptional ones.

5. Increase chances of learning: WEST provides four levels of advice:

   1. Isolate a weakness and directly address that weakness.

   2. Delineate the space of possible moves at this point in the session.

   3. Select the optimal move and tell why it is optimal.

   4. Describe how to make the optimal move.

6. Environmental considerations: At times be forgiving of possible careless errors made by the student, if it is obvious that the student knows better, This is indicated by a pattern which will emerge from student handling of Issues.

2.1.3.5 WUMPUS -

The WUMPUS system is an ICAI program that acts as the coach in a computer game in which the player tracks down the vicious WUMPUS and at the same time avoids deadly pitfalls, (Carr and Goldstein, 1977). The player must be armed with knowledge of logic, probability, decision-making theory and geometry. The lack of knowledge on the part of the player may result in being devoured by the WUMPUS or falling to the center of earth. Students are motivated to learn in keeping with the philosophy of computer coaching.

2.1.3.5.1 THE WUMPUS MODEL -

The WUMPUS system is composed of four modules:

1. The tutor module.

2. The student module.

3. The expert module.

4. The psychologist module.

The expert evaluates the player's move and informs the psychologist of how good or bad the move is and what skills are needed by the player to find a better alternative move. Armed with this knowledge the psychologist forms hypotheses into the Student model. This knowledge becomes part, a subset, of the expert's skills. The tutor uses the student model to guide its dialogue with the player, (Goldstein, 1977).

Figure WUMPUS represents the WUMPUS model. It contains the four modules plus a problem-solving knowledge base. This is basically the syllabus of the material. The expert and the student models depend mostly on the skills represented in the database. Based on a model of difficulty of the material contained in the syllabus, the psychologist decides which skills the student is expected to acquire in the next move. The tutor deals with relationships between skills such as analogies and patterns which can be used to improve its explanations of new skills, (Goldstein, 1979).

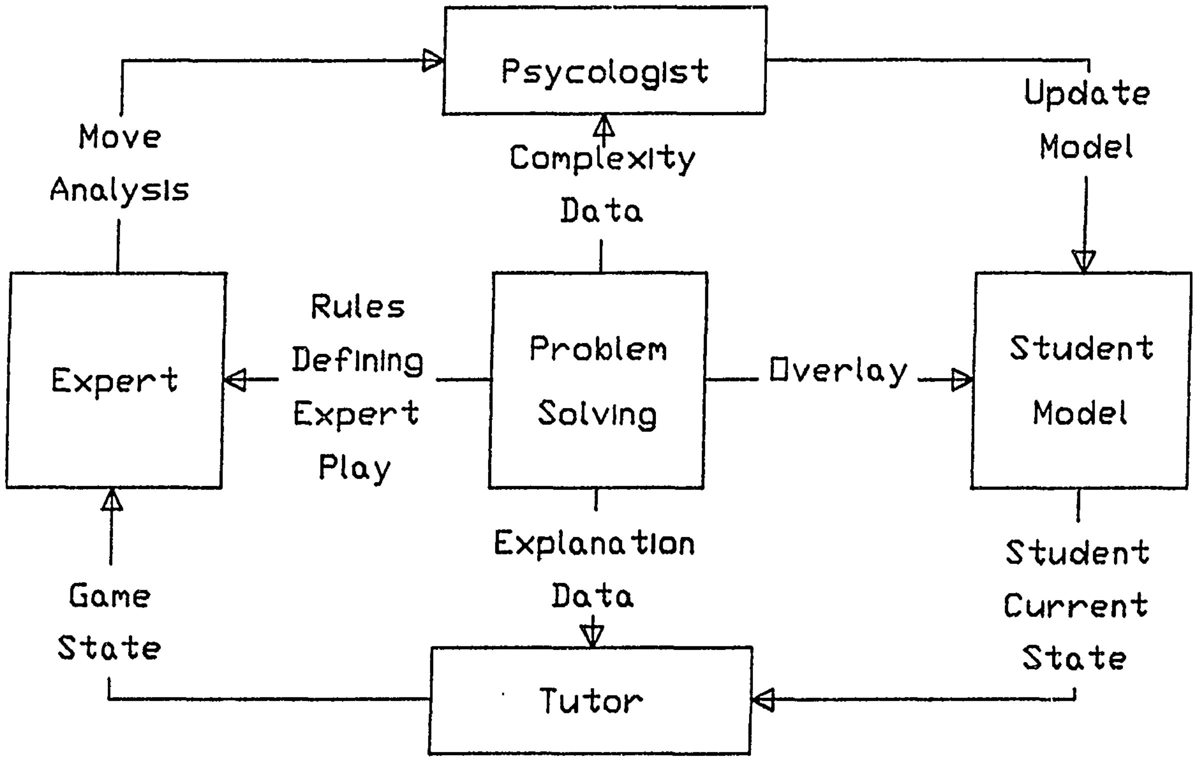

FIGURE WUMPUS

MODEL OF A COMPUTER COACH (GOLDSTEIN, 1979)

2.1.3.5.1.1 THE PSYCHOLOGIST MODULE -

The psychologist makes reasonable hypotheses about which skills the player possesses that are contained in the expert module by an application of the rules of evidence. The following are typical rules of evidence:

1. Increase the probability that a player possesses a skill if, the player explicitly claims aquaintance with the skill and the skill is manifest in the player's behavior.

2. Decrease the probability that a player possesses a skill if, the player expresses unfamiliarity, the skill is not manifest in a situation in which the expert believes it to be appropriate, and there is a long interval since the last confirmation was received.

2.1.3.5.1.2 THE TUTOR MODULE -

The Tutor selects appropriate topics to discuss with the player using "explanation rules" and to choose the form of the explanation to present to the player. The following are types of rules:

1. Simplifications rules: that simplify complex statements into understandable explanations.

2. Rhetorics: that combine alternative explanation strategies. Explanations are expressed in terms of a general rule on one extreme and in terms of a specific instance on the other.

2.1.3.5.1.3 The EXPERT MODULE -

The expert module works by placing the player somewhere in a randomly connected warren of caves adjoining his/her cave. The goal of the player is to find the WUMPUS and slay it with an arrow. Each move results in a neighbouring cave which yields information regarding that cave's neighbours. The difficulty in choosing a move arises from the various dangers in the warren, bats, pits and the WUMPUS itself. The following things may happen if the player makes a "bad" move:

1. If the player moves into the WUMPUS den, he/she is eaten.

2. If the player walks into a pit, he/she falls to his/her death.

3. Bats may pick the player up and randomly drop him/her elsewhere in the warren.

Thus if the player makes the proper logistic and probablistic inferences then the player will minimize the risk and find the WUMPUS. Warnings are provided to the player by the expert whenever he/she is near danger. Warnings are:

1. The WUMPUS can be smelled within one or two caves.

2. The squeak of bats can be heard one cave away.

3. The breeze of a pit can be felt one cave away.

The player wins the game whenever he/she shoots an arrow in the WUMPUS den. If the player exhausts all five arrows without hitting the WUMPUS then he/she loses the game.

The expert module represents its expertise, i.e. knowledge, in a rule-based representation. There are twenty rules in WUMPUS, five of which follow:

1. Positive Evidence Rule: A warning of the existence of danger in one cave means or implies the absence of danger in the neighbouring cave.

2. Negative Evidence Rule: The absence of a warning implies that no danger exists in any neighbors.

3. Elimination Rule: If a cave has a warning and all but one of its neighbors are known safe, the danger lies in the remaining neighbor.

4. Equal Likelihood Rule: In the absence of knowledge all of the neighbors of cave are equally likely to contain a danger.

5. Double Evidence Rule: Multiple warnings increase the probability that a given cave contains a danger.

2.1.3.6 GUIDON -

Guidon is an ICAI application that is designed to teach diagnostic problem solving. It is developed at Stanford University by William J. Clancey. MYCIN is a medical consultation system used for diagnostic purposes of a patient suspected of having an infection. MYCIN uses the infectious-disease diagnosis rules as the skills to be taught. Clancy has developed GUIDON as the teaching part of the system and used MYCIN to provide the topics to be discussed and with a basis for evaluating the student's behavior. The teaching knowledge is separated from MYCIN explicitly in the form of some two hundred rules that include methods for guiding the dialogue, presenting diagnostics, constructing a student model and responding to students initiatives. The separation of teaching from the domain knowledge base MYCIN's infectious-disease knowledge base, can be replaced with another diagnostic rule for another domain.

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Rules are plausible and a good vehicle for teaching, (Buchanan, 1979) for three reasons.

1. They are designed to capture a significant part of the knowledge necessary for good problem-solving. This has been demonstrated at Stanford School of Medicine formally by an evaluation of MYCIN which showed that it was just as competent as the medical faculty members in selecting antimicrobial therapy for meningitis and bacteremia.

2. The rules are flexible to use because of the provision of representing meta-knowledge which allows a program to analyze rules and reason about components.

3. Rules are expressed in terms familiar to humans, so that reading back a line of reasoning to a student might be helpful.

GUDION uses a Tutoring dialogue and a Student model to interact with the student. The Tutoring dialogue is a "mixed initiative dialogue, one in which the student or the system may initiate a line of reasoning and follow up with it. GUIDON is very flexible in responding to the student's initiative. It allows the student to specify what he/she knows, wants to know and wants to ignore. The excerpt below demostrates GUIDON's flexibilty:

First the student starts by asking about the subgoals relevent to his/her topic, which the system extracts from MYCIN's rules.

STUDENT: Factors

GUIDON : The following factors will be useful to determine the type of the infection:

1. Whether the meningitis is partially treated.

2. Whether a lumbar puncture has been performed on pt. 538.

3. The duration of the neurological signs.

4. The CSF protein.

5. Whether Pt 538 has a rash consistent with herpes Zoster.

STUDENT: Use 3.

GUIDON : The duration of the neurological signs is 7.2 hours using othe information available to you now, the duration of the neurological signs enabeles you to conclude what the type of the infection is bacterial (.2) viral (.2) [RULE 524]

STUDENT: I know 2.

GUIDON : Good. MYCIN has also made a decision. The site of CULTURE-1 is evidence that a lumbar puncture has been performed on Pt. 538 [RULE 112].

Back to our discussion of the type of the infection...

Summary of evidence that the type of the infection is

bacterial (.98):

1. The fact that the meningitis is partially treated (.95) is

   evidence that the type of the infection is bacterial (.19)

   [RULE 148].

2. The WBC from the CSF and the percent of PMN's in the CSF is

   evidence that the type of the infection is bacterial (.9)

   [RULE 501].

The GUIDON knowledge base includes finding, hypotheses rules, tasks and relations. Any data that can be infered from rules are findings which can be generally observed or measured. Hypotheses are infered from rules, they cannot be measured. Hypotheses in the MYCIN knowledge base include diseases and pathophysiological states. Relations refer to medical calculus relations and include subtype causes (Clancey, 1982).

The GUIDON knowledge base also includes facts (data) about findings and hypotheses as defined by relations (e.g. meningitis is a subtype of infection, headache is a finding, and so on). It also contains the diagnostic procedure and domain rules (e.g. if the patient has double vision there is suggestive evidence for intracarnial pressure). "Dynamic knowledge" is situation specific and refers to information that becomes known only during a problem-solving session (e.g. mary's temperature is 102 degrees).

MYCIN uses a diagnostic strategy known as heuristic classification problem solving (Clancey, 1982). Given an enumerated set of solutions (e.g diseases of possible diagnoses), MYCIN heuristically maps a set of findings into one or more possible solutions. This diagnostic procedure is represented as tasks which are procedures that are stated in a declarative rule-based language (Figure GUIDON-1). When a task is invoked, one or more of its meta-rules are applied (Figure GUIDON-2). MYCIN also uses a concept known as the differential which is defined as the set of hypotheses currently being considered. Diagnosis or solutions are represented in a tree and the differential represents a cut through this solution space.

Conclusions in a consultation are associated with certainty factors that represent a degree of belief. Each hypothesis has both a certainty factor (CF) and a cumulative certainty factor (CUMCF). The CF represents the combined certainty of all rules that have concluded directly about the bypothesis. The CUMCF represents a combination of the CF of a given hypothesis with CF's of its descendants in the disorder taxonomy. To illustrate evidence for meningitis (a positive CF) increases the CUMCF of infectious process because meningitis is a subtype of infectious process. This necessarily means that negative CF's of ancestors are also combined; therfore, evidence against infection can decrease the CUMCF of meningitis.

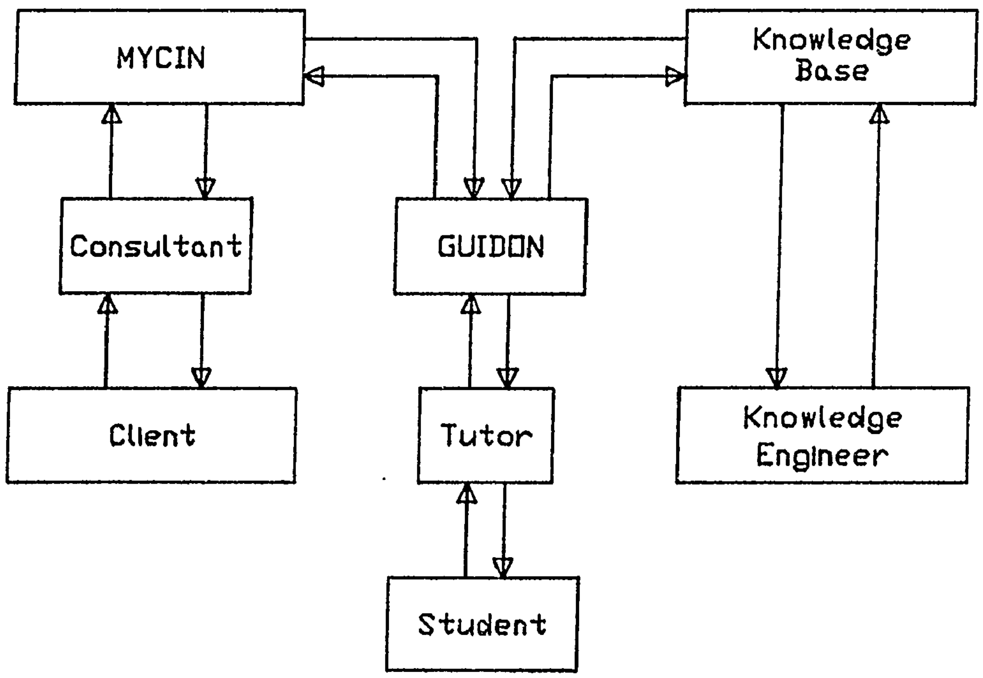

FIGURE GUIDON-1

THE GUIDON MODEL

IF

1. The patient has a stiff neck on flexion, and
2. The patient has a headache

THEN

If you are considering infectious-process, there is suggestive evidence (.5) that the patient's infection is meningitis

FIGURE GUIDON-2

A DOMAIN RULE

2.1.3.6.0.1 The STUDENT MODULE -

When a session begins with a student GUIDON calls on MYCIN to "solve" the case to be presented to the student. The data or output of the solution of the consultation, consisting of MYCIN's rule conclusions and records of why rules did not apply, are reconfigured into a complete logic tree of goals and rules. The rules are indexed by the goals they conclude about and the subgoals or data needed to apply them. During the tutorial session, as the student inquires about the patient and receives more case data, the information provided and collected is used to drive MYCIN's rules in a forward direction. Thus at any one time some of the rules would have yielded a conclusion and others will require more information.

The record of what the expert (i.e. in MYCIN) "knows" at any time during the student-run consultation forms the basis for evaluating a student's partial solutions and providing assistance. The model here assumes that a student's knowledge is a subset of the experts (MYCIN) knowledge base and that there are unique reasoning path for making a particular deduction.

The student model is composed of three components depicted in figure GUIDON-3. The three components are USE-HISTORY, STUDENT-APPLIED and USED.

USE-HISTORY is represented as a "certainty factor", that combines the background evidence with the implicit evidence stemming from needs for assistance and verbalized partial solutions and from the explicit evidence stemming from a direct question that tests knowledge of the rule.

STUDENT-APPLIED records the program's belief that the student is able to apply the rule to the given consultation. That is to say that the student will refer to the rule to support a conclusion about the given goal. The model thus distinguishes between knowing a rule (USE-HISTORY) and being able to apply it (STUDENT-APPLIED). A student for example may know the data in subgoals but is unable to achieve them.

The third component of the Student Model is called USED. This component records the program's belief that the student would mention a rule if asked to support his/her partial solution. The record of what rules the student is able to apply (STUDENT-APPLIED) or use, are combined with indirect evidence by comparing conclusion made by rules with the student's conclusions and with evidence that the student may have remembered to apply in an earlier dialogue. This combined evidence feeds back into the USE-HISTORY module and affects the way the program responds to the partial solution and feedback to the student model.

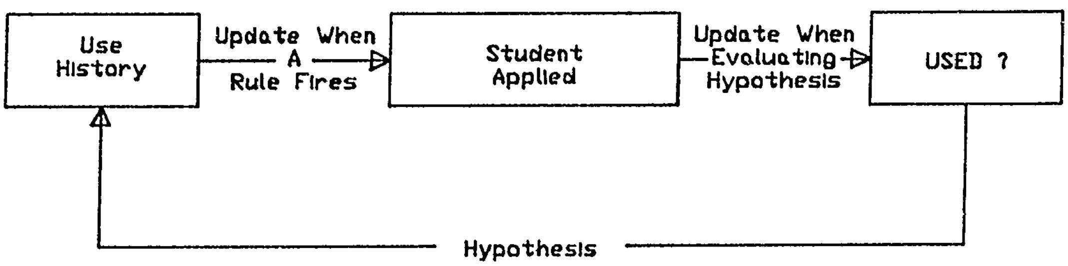

FIGURE GUIDON-3

STUDENT MODEL COMPONENTS

2.1.3.6.0.2 GUIDON TUTORING STRATEGIES -

GUIDON uses various tutoring strategies and styles. Opportunistic tutoring is one strategy in which presentation methods "opportunistically" adapt material to the needs of the dialogue. The tutor is sensitive to how a tutorial dialogue is composed, what interruptions and probing are necessary in this kind of situation. GUIDON corrects the student before quizzing him/her about "missing hypotheses," asks questions about recently mentioned data to test his/her understanding of its use, quizzes him/her about rules, follows hints and comments on the status of a problem.

GUIDON also uses a pedagogical style implicit in it's teaching rules. It provides short orientation lectures to the student, using tutoring rules. The tutoring process is governed by the following principles:

1. Provide assistance, methodically introducing small steps that will contribute to the problem's solution. Assistance should be general and should remind the student with strategies he already learned and to encourage the student to advance the solution using case data he/she already used.

2. Probe the student's understanding by responding with partial solutions.

3. Examine the student's understanding and introduce new information whenever there is an opportunity.

4. Be Perspicuous by having an economical presentation strategy and adhere to conventional patterns.

5. Provide orientation to new tasks by giving an organized considerations he/ she should be making without giving away the solution to the problem.

6. Strictly guide the dialogue by indicating the end of a topic and when inferences are complete.

GUIDON research clearly demonstrates the advantages of separate, explicit representations of both teaching knowledge (i.e methods, style, strategies) and subject matter. It shows that the sudent should be taught non-trivial problems in which he/she can excercise his/her wits. The GUIDON research also demonstrated that the needs of tutoring can direct research toward more psychologically valid representation of domain knowledge, which will benefit other research of expert systems that require human interaction particularly those of knowledge acquisition, access and utilization.

2.1.4 CONCLUDING REMARKS

The Intelligent Computer Assisted Instructions systems discussed in this chapter teach subject matter of various disciplines. They use a variety of learning approaches and techniques. The literature shows that Artificial Intelligence techniques are best suited for a "learning by doing" environment. Software programs running on appropriate hardware and suing AI technology can provide efficient tools for a rich learning experience.

The research presented here sruggles with the complexity of knowledge representation, aquisition and utilization. This struggle can result in providing learning environment where learners can deal with complex ideas without formal schooling. This is strongly suggested by the great diversity of human cultures and the ability to observe. Learning by doing which is the method AI is best suited for, is strongly supported by the works of Piaget and his colleagues (Piaget and Inhelder, 1969). The literature reviewd in this chapter is greatly oriented towards implementing the "learning by doing" method as is the case in the GUIDON work. Artificial Intelligence software thus far developed provides its own feedback mechanism so that leaves no room for the traditional "teacher" role in the learning by doing environment.

The question is then if learning by doing is the way to go then waht are good tools to give to the student who is learning by doing?. Some of the techniques of the research of this chapter such as the GUIDON research have tried to demonstrate some of the tools for learning. Review of the research thus far done in the area of applications of AI to education did not provide imperical data to support the claims of the research on the effectiveness of the software systems of ICAI. Research in this area has been concerned mainly with the implementation and internal verification of the computer programs. Also the learning procedures, dialogues, knowledge representation have been the center of investigation without scientific testing of the effectiveness of the applications to education. Testing is done to debug the software as part of the programming efforts. The lack of imperical data in the literature strongly seggests the need for testing. The claim that ICAI provides feedback and effective tools must be supported by imperical data. Also testing should be done in different cultural and ethnic environments using more variety of subject matter.

This research is aimed at developing and adapting ICAI software and field test it to provide some imperical data on the subject. Much more research is needed before the effectiveness of this AI technology can be accepted. The principles and methodology of scientific research must be applied in order to obtain the desired imperical data proving the effectiveness issue raised by this research. Such scientific methodology for carrying out this investigation is presented in the next chapter.

CHAPTER 3

METHODOLOGY

3.1 POPULATION

This experiment was designed to test the effectiveness of applying the AI computer-based intelligent tutoring technology. The population was chosen as the entering freshman "arts" students registering for CS103; "introduction to computers" because this class of students had never been subjected to any knowledge about computers, as Jordanian high schools did not teach this subject matter at the time this research was conducted. This meant that the students were assumed to have little knowledge about computers. The curriculum (see Appendix A) for the course CS103 had been used as provided by the Computer Science Department at Yarmouk University at the time of this study.

Students who took part in the ICAI research or the experimental group were selected as follows:
Registration of all students at Yarmouk University for the fall semester of 1986 took place between September 7th and the 14th, 1986. Instructions began on September 20, 1986.

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The drop/add period extended from September 20 through September 28th, 1986. Registrations and add/drops were all entered into the University's computer system. The population for this study was taken as all the students registered for CS103 course immediately after the add/drop period. This population was 912 students of which 47% were females and 53% were males.

3.2 SAMPLING

A computer program was prepared by the researcher to draw a sample (experimental group) of 40 students from the population, randomly using the following randomizing function algorithm:

Let S=DSEED. Then deviates R(i) where I=1,2,...,N are generated

by SO = DSEED

S(i) = (7**5)*S(i)*(MOD((2)**31-1))

R(i) = (2**(-31))*s(i)

This generator is reported in IMSL.

Five samples of 40 each were drawn and the one that approximated best the male/female ratio in the population was chosen. The Computer Science Department then separated the

40 students chosen in the sample into one section called "the experimental ICAI" section.

3.3 DESIGN OF THE EXPERIMENT

The random sample or the E-Group was given the treatment. The balance of the population constituted the control group designated the C-group. Since the C-group was the remainder of the population and was twenty times as large as the E-group then it was a "non-equivalent" group. In the terminology of statistical designs of experiments this would fall in the category of "time series measures non-Equivalent experimental control group designs" described by Fitz-Gibbon and Morris (1978) as "design number 5". The E-Group were tutored by the computer "intelligent" program while the C-Group were taught as usaul by an instructor the traditional-lecture way. The course or subject matter taught was introductory computer science course CS103 taught routinely to entering "arts" freshman students. CS103 general computer science knowledge was chosen because it lends itself to be represented in rules which will make the tutoring program look more like a human expert.

3.4 RESEARCH INSTRUMENTS

The ICAI research conducted in this study uses three

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instruments:

1. Achievement tests.

2. Evaluation questionaire.

3. Notes of the researcher.

Achievement tests were prepared jointly by all the teachers of course CS103 and were conducted at the same time for all students of CS103 including those of the experimental group. The tests were also corrected by all teachers using answers agreed upon by all the instructors. Each instructor received the test papers and results for students taught by him/her including the ICAI experimental group supervisor (researcher).

Two Attitude Evaluation Questionaires were prepared. One was for the experimental group for evaluation of the ICAI technique. The second questionaire was prepared to be filled by all course CS103 students.

Notes of the researcher are not used to test the hypotheses of this study. Information contained in the researchers notes are important to the conduct of the research and to make general conclusions about the behavior of the students which otherwise will be difficult to measure such as cultural motivated behavior. As an example of such behavior is the general remarks the student may make about computers and their relevance to society.

3.5 DATA COLLECTION

The experimental group was scheduled for instruction. The time of instruction using the computer was assigned based on the choice of the student. The group was also given an orientation on the research and the ICAI program and how it works. The students then started to use the ICAI Intelligent Tutoring System (ITS) described below, running on the IBM-PC XT computer. The student was allowed to consult computer science references if they felt a need for it. The student is tutored by the ICAI program as described under ICAI tutoring module.

Three tests were conducted for all CS103 students. Two mid-terms and one final. The tests were prepared jointly by all teachers of CS103 including the ICAI section researcher. Sample tests are described below under "Research Instruments". The attitude evaluations are done at the end of the treatment or course only, unlike the achievement tests which are administered three times. Attitude Questionaires were distributed along with the final examination or achievement test at the end of the semester. All students (the entire population) were asked to answer the questions in the achievement test and to fill out the Attitude Questionaire. The achievement test scores and the attitude questionaires were then collected. The scores from the first, the second mid-term exams and the final scores were collected and prepared for computer data entry. Also the

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Attitude Questionaires were coded in special data sheets for computer data entry. All data collected was entered into the computer for analysis by the SPSSX program.

HYPOTHESES

The hypotheses of this study concerned the effectiveness of knowledge based expert systems techniques of AI in developing computer based intelligent tutoring and attitude of students and were formulated as follows:

1. Null hypothesis (HO): The Null hypothesis states that there is no statistically significant difference in the mean of the multi-variate vector of the attitude and the achievement test scores of students taught by the ICAI method and the traditional lecture method. In other words the mean of the multi-variate vector attitude and achievement of the E-group is equal to the mean of the multi-variate vector attitude and achievement of the C-group.

   Mathematically expressed as:

   $$HO: \quad U(E) = U(C)$$

   Where U(E) is the mean of the multi-variate vector of attitude and achievement of the E-group.
   And U(C) is the mean of the multi-variate vector of attitude and acievement of the C-group.

2. The alternative hypothesis (H1): The alternative hypothesis states that the mean of the multi-variate vector of the attitude and achievement test scores of students taught by the ICAI method is greater than that of the traditional lecture method.

Mathematically expressed as:

$$H1: \quad U(E) > U(C)$$

If HO were rejected in favour of H1 (i.e. the performance of the E-group is superior to that of the C-group) this would provide evidence of the effectiveness of the ICAI method on the achievement and attitude of the students. On the other hand if HO were not rejected at the 5% level of confidence, then this would imply that the performance of the experimental group is at least as good as that of the C-group. The effectiveness of the ICAI method in either case would be established since the technique of using ICAI tutoring by computer performed as well or better than the traditional teaching method.

Similarly the univariates student attitudes and acievement test scores were tested. In other words, hypotheses were formulated to test the performance of the E-group as compared to the performance of the C-group on the basis of achievement and attitude separately.

3.6 LIMITATIONS AND ASSUMPTIONS

A source of difficulty in carrying out an investigation and evaluation is the adherance to a set of parameters. Adequate definition of the limitations concerning the nature and scope of an experiment must be stated. Without such definition, the application and the social significance of the research suffers. It is also equally true of the definition of the population to which the study applies its research. The validity of the experiment would also be questionable without putting limitations on the scope of the study and the definitions of constructs on the one hand, and without testing the assumption's underlying the statistical models applied on the other. The delimitations and clear definitions of the parameters of the study are also necessary to facilitate the replication of the experiment which is essential for scientific credibility.

The research on the other hand, cannot be too specefic at the expense of using limitations rather than using proper experimental structure and design that make the study meaningful and replicable. The experiment and the conditions under which it was conducted must be duplicated and applied in order to contribute to the body of knowledge. Thus keeping these concerns in mind, the limitations and assumptions of this study were formulated.

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This study is conducted with "arts" freshman students (see chapter I) of Yarmouk University. Although Yarmouk University has some students who are culturally not Arab/Islamic, none of the students enrolled in the course CS103 in the Fall semester of 1986 were as such. The implication in this study is that what may be applicable in the Western culture may not be necessarily applicable in an Arab/Islamic culture and vice versa. This is the main difference between this investigation and similar investigations conducted in the Western Societies. In view of this, population of the study, especially the sample selected for the experiment, would represent the general Arab/Islamic student populations in Jordan but to a limited degree.

The sample size E-Group is chosen to be 40 with a ratio of 49% females to 51% males. This approximates the ratio of females/males in the population; the C-Group. Although care was taken that the male/female ratio in the experimental group be representative of the ratio found in the limited population defined for this study, this ratio is by no means representative of the male/female ratio of the students in Jordanian universities.

This study cannot detect or control the interaction between sex and the treatment or the differential effect of treatment on male and female students. There are always unforseeable factors that may pose potential threats to internal and external validities of the results. The researcher assumed that the Hawthorne and novelty effects will level off by the end of the semester.

One potential threat to internal validity of the results could be the experimenter's unconscious bias. The control group students were taught by several instructors but the E-group was taught by the computer and supervised by the researcher himself. Obviously strict scientific neutrality was observed by the researcher, nevertheless, it should be pointed out that positive effects, to a minimal degree of the unconscious motivations of the experimenter on the achievement of the E-group students cannot be strictly ruled out.

Finally, the usual assumptions underlying the multivariate analysis of variance model were held and checked out by appropriate means. No outstanding departures either from multivariate normality of distributions or homogeniety of the dispersion matrices were suspected on the basis of the observed data.

ICAI reseachers have used several tutoring strategies. Mixed-intiative, coaching, consultation and the Socratic are some of these strategies. Some research uses more than one at the same time. Most use only one in the design of ICAI programs to avoid complexity and unreasonable response time from the machine. The "consultation" strategy is characterized by "learning through an expert". This study is limited to the use of the "consultation" approach typical of expert systems techniques used in the GUIDON research conducted by Clancey,(1979).

As there are several tutoring strategies of which this study is employing "consultation", so there are several techniques of AI. This study is limited to the use of knowledge based expert systems techniques in the design of the ICAI program of this study. The knowledge base is represented in rules and the tutoring strategy is modeled separately as the expert who uses problem solving procedures similar to those of an expert in a given domain. The subject matter or knowledge base is in the domain of computer science and it is limited to an introductory knowledge in the subjects as defined by the curriculum of CS103 at Yarmouk University.

The study is also limited to measurements of achievement as measured and defined by the test during and after the completion of the course and to attitude measurements of both the E-Group and the C-Group.

3.7 METHODOLOGY

VARIABLES

METHODOLOGY

The independent variable of the study was the treatment via method of teaching which had two levels:

1. The ICAI method of teaching called the experimental method.

2. The traditional lecture method.

The dependent variables of the study were achievement and attitude of the students.

1. Achievement was defined in terms of the course objectives and measured by achievement tests during the conduct and at the conclusion of the course.

2. Attitude of the learners towards the course and the method of teaching was measured by the scales designed by the researcher for the purpose of this study.

The teaching methods as well as the student evaluation procedures are described below.

3.7.1 DESCRIPTION OF THE RESEARCH PROCEDURES

3.7.1.1 ICAI Method Of Instruction -

3.7.1.1.1 THE INTELLIGENT TUTORING SYSTEM (ITS) -

The ICAI program used in this experiment is an Intelligent Tutoring System (ITS) based on research into Intelligent Computer Assisted Instruction that contain expertise on the domain they are teaching. ITS allows two-way interaction. The system controls the learning lesson planned by presenting the student with a menu of problems to be solved. The student chooses a problem to solve or the system may choose a problem based on the student's knowledge profile. The system questions the student about his/her problem-solution and as the student provides information presumably leading to a solution the system interacts with the knowledge base to find an explanation of where the student is going wrong. The ITS system maintains a student model, which contains information about the level of knowledge of the student. It uses this knowledge to guide the tutoring strategy in such a way as to concentrate more on tutoring efforts where the student needs more training. As the student progresses, learns and answers questions the system keeps track by recording what the student knows or does not know.

The ITS program incorporates three elements to do its job:

1. Knowledge of the student.

2. Knowledge of the subject.

3. Consultation dialogue with the student.

The (ITS) program teaches a variety of subjects as long as these subjects are well defined and lend themselves to being represented as rule-based programs. This is important to ITS since it utilizes a rule-based representation of the subject expertise in order to impart knowledge of the subject. This is a continuation of the line of research undertaken by SOPHIE (Brown et al, 1975) and GUIDON (Clancey, 1982), see also Chapter II. By representing knowledge in rules ITS "executes" the set of rules and, on the basis of a comparison of its solution to a student's, provide a critique of the student's misconceptions. The goal of training is also clarified by pointing out the rule-path to the right solution. The program is used by the student mainly in a consultative role and misconceptions are corrected and recorded in the knowledge base for future use.

ITS, also as used in this research, provides individualized learning by adapting its pattern of behavior to suit a particular student. The student model is designed to recognize a rule which the student was not taught, a rule he has not mastered, and a rule that he/she uses properly. This type of model is called overlay-model (Goldstein, 1979).

This means that the model describing the student state of learning is mapped onto or overlays the rules being taught. The program structure is designed around three modules described below and is depicted in (figure ITS).

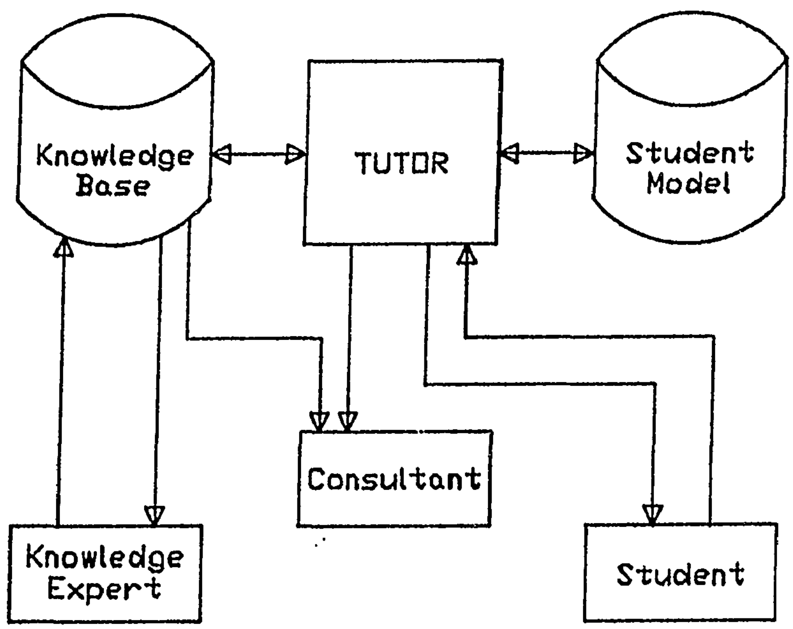

FIGURE ITS

INTELLIGENT TUTORING SYSTEM (ITS)

3.7.1.1.2 The (ITS) Program Knowledge Base -

The subject taught by ITS is computer science. It is general knowledge about computers which is meant to introduce entering freshman students to the subject of computers. It is general knowledge about the computer and computer science and lends itself to rule-base knowledge representation. The actual knowledge base of ITS which is used in the conduct of this research is included in Appendix A. The tutoring module links the knowledge base and uses it in problem-solving dialogues. These rules represent the subject matter knowledge, namely, the general introduction to computer science that the tutoring module attempts to impart to a student. A "concept" is represented as rules (Appendix A). The rules are used to provide a solution to a task given to a student. The solution is compared to the student's solution and the correctness of the solution is verified. It also informs the student of his/her misconception. The rules are also used by the tutor in a consultative mode to provide students with task competence information about the subject.

3.7.1.1.3 Tutoring Module -

The tutoring module of ITS uses a teaching strategy by presenting a topic to be learned by the student. It then proceeds with a dialogue asking the student questions pertaining to the problem. The student asnwers based on his/her approach or knowledge of the problem. The system leads the student on without an attempt to correct or volunteer a solution leaving it to the student to provide the solution. When the chain of rules in the expert knowledge base is exhausted or a wrong solution has been reached, the student's approach is then displayed and the student analyzes the path of his/her solution that led to the wrong solution. The student is then allowed to make modification about his/her misconceptions and the process is repeated iteratively. Every interaction through the dialogue, the student learns about his/her misconceptions and makes adjustments. When the student has corrected all his/her misconceptions the system reaches the right solution and the student has "mastered" or learned the rules involved in the solution.

The tutor at that point updates the student's knowledge profile in cooperation with the student module. In essence ITS tutoring strategy is to let the student "learn by doing", experiment, evaluate and analyze. It achieves this by presenting the student with a menu of lesson plans and the use of simple question/answer dialogue employing simple natural language. An example of an ITS dialogue follows.

3.7.1.1.4 STUDENT MODULE -

The student module is designed to keep track of the student's progress. It achieves its objectives by storing a knowledge profile of the student. It also decides which rules the student has "mastered" which rule(s) the student needs to practice more in order to "master" and which rule(s) he/she did not use at all. The student module also communicates the states of the student's progress to the Tutor and provides it with advice on what are the student's weaknesses and strengths.

3.7.1.1.5 DIALOGUE -

The dialogue used by ITS was dveloped with the student users in mind. As previously was pointed out the students are of Arab/Islamic culture. The research was conducted in the English language. The ability of the students to deal with the English language is limited. Therefore a dialogue had to be employed such that the student will have a minimum difficulty but at the same time comprehend the dialogue.

In order to implement a strategy in the dialogue that will satisfy this requirement a dialoque with minimum display of words and minimum of sentence composition on the part of the student had to be used. It was decided to use a dialogue similar to the game of "twenty questions". The strategy includes the student's need to know what he/she wants to learn, such as the central processing unit of the computer. The system will present questions about the central processing unit and if the student provides the right answers then the path will lead to the solution or knowledge about the issue being discussed. An example of a dialogue where the student answers with minimum words follows:

System: Does it represent an event or fact?

Student: Neither

System: Is it ontained by processing data?

Student: No

System: Is it a piece of data?

Student: No

System: Is it a set of items of data?

Student: No

System: Is it a set of data records?

Student: No

System: Is it a collection of interelated files?

Student: No

System: Is it a mode of computer processing?

Student: Yes

System: Is data entered at the source?

Student: Yes

System: Is output or data transmitted directly where used?

Student: Yes

System: Then it is an "online" system of processing data.

One can easily notice how the computer is always leading and how the student must have appropriate knowledge to answer properly. If the student did not provide the right answers then it leads to the wrong conclusion and the system in that case provides the student with analysis of his/her misconceptions. It is also noted that the student provides minimum words with maximum information.

3.7.2 TRADITIONAL LECTURE TEACHING

Course Computer Science 103 at Yarmouk University had 848 students. The students in the course were distributed into sections as follows:

	No. of students	Teacher
Section 1	151	A
Section 2	196	B
Section 3	180	B
Section 4	135	B
Section 5	122	A
Section 6	39	C
Section 7	25	ICAI tutor

Lesson plans were provided to the teachers by the Department of Computer Science including the ICAI researcher. The plan covered subjects to be taught, schedule of teaching and specific references. Each teacher prepared his/her own notes and used a mixture of Arabic/English language instructions. Tests were prepared jointly by all teachers. All students whether they were taught the traditional or the ICAI method took the tests at the same time.

3.7.2.1 ICAI INSTRUCTION PROCEDURE -

The ICAI instruction procedure for course CS103 followed the plan provided by the Yarmouk University Computer Science Department. The knowledge expert (researcher) prepared the lesson subject matter represented in rules then updated the knowledge base using the Kowledge Base Module of the ICAI program. The rules were entered into the knowledge base via a special "editor" built into the Knowledge Base Module. The knowledge base rules for the entire course CS103 are included in Appendix A.

3.7.2.2 TRADITIONAL LECTURE PROCEDURE -

The section-teacher of course CS103 prepared his/her own lecture notes guided by the subject teaching-plan provided by the Computer Science Department at Yarmouk University as it existed in the fall semester of 1986 academic year. Students had also been given a set of computer science references for course CS103 for extra reading. The teacher presented the material from his/her notes. The teaching style, the amount of homework and the extra reading assigned was left up to the individual teacher.

CHAPTER 4

RESULTS

4.1 INTRODUCTION

As stated in Chapter I the purpose of this study was to investigate the effectiveness of the ICAI tutoring method in comparison with the traditional lecture method on the achievement and attitude of the first year computer science students in the Arab/Islamic cultural environment. Since both male and female students constitute the population of this study, the hypothesis of gender differences in achievement attitude and treatment impact were also tested. The data were collected on three (First, Second, and Final) exams of achievement which were conducted over the course of one academic semester (four months), and a composite measure of attitude described earlier in Chapter III. The data were analysed using both multivariate and univariate analyses of variance. The result of the statistical analyses are presented in the following paragraphs without any attempt to interpret them at this stage. Interpreation of results will be presented in the next chapter.

4.2 BASIC DATA

As stated in the previous chapters, 25 students were randomly selected for the experimental group, from all the students who took the course Computer Science 103. The number of students who completed the course taught by the traditional lecture method was 823. All the students enrolled for the course took the three achievement tests, but the attitude measure was administered to the 25 experimental group students and to a group of 50 students randomly selected from the 823 control group students. Therefore, achievement test results of the experimental group can be compared with the remainder of the students of CS 103 i.e.,823, or with a randomly selected sample of 50 out of 823. Both comparisons will be presented. The attitude scores of the experimental group can only be compared with those of the 50 random sample of 50.

RESULTS

TABLE 1

Means and Standard Deviations of Male/Female Experimental/Control Group Students of various Achievement and Attitude scores (N=75)

		GROUP					
		Experimental N=25			Control N=50		
		Male N=11	Female N=14	Total N=25	Male N=29	Female N=21	Total N=50
Ach First Test							
	Mean	23.91	22.14	22.92	21.41	20.86	21.18
	Sd	3.42	4.22	3.92	3.92	3.89	3.88
Ach Sec Test							
	Mean	25.91	23.86	24.76	22.24	21.00	21.72
	Sd	2.98	2.93	3.07	4.77	4.92	4.82
Ach Fin Test							
	Mean	30.82	28.57	29.56	26.48	28.38	27.28
	Sd	3.97	2.68	3.43	4.77	3.75	4.43
Ach Total							
	Mean	80.64	74.57	77.24	70.14	70.24	70.18
	Sd	5.80	7.50	7.34	8.43	10.58	9.29
Material							
	Mean	13.27	12.43	12.80	10.65	11.33	10.94
	Sd	1.61	2.65	2.26	2.53	2.65	2.58
Teacher							
	Mean	19.18	20.50	19.92	20.21	21.91	20.92
	Sd	3.60	4.99	4.40	4.11	3.45	3.90
Q4							
	Mean	2.00	1.79	1.88	1.45	1.48	1.46
	Sd	.78	.43	.60	.63	.51	.58
Q6							
	Mean	1.55	1.64	1.60	1.65	1.57	1.62
	Sd	.52	.50	.50	.48	.51	.49
Total							
	Mean	36.60	36.36	36.20	33.97	36.29	34.94
	Sd	4.54	7.65	6.35	5.45	5.46	5.52

RESULTS

Table 1, presents the means and standard deviations for each one of the four (Sex by Treatment) groups (N= 25 for treatment, and 50 for control) on the four achievement and five attitude scores. Four achievement scores are:

1. Score on the first achievement test administered about 40 days from the starting of the term.

2. Score on the mid-term achievement test.

3. Score on the final achievement test administered at the end of the term, and

4. The total score i.e., the sum of the three test scores.

The first test as well as the mid-term test carries a weight of 30 percent each, whereas, the final examination accounts for the remaining 40 per cent of the full marks.

The five attitude scores are:

1. Material score, the sum of responses on four questions (Nos. 1, 2, 3, and 5 in the attitude scale) concerning the appropriateness of the amount and type of contents of the course.

2. Teacher score computed by summing over seven questions (Nos. 7, 8, 9, 10, 11, 13, and 14) pertaining to teacher related characteristics.

3. Question 4, the score on question 4 (Do you feel you can converse about computers ?) of the attitude questionnaire.

4. Question 6, the response score on question number six of the questionnaire (Do you feel the time was enough to cover the material?).

5. The total score, the sum of the above stated four sub-scale scores.

The mean and standard deviations of the experimental group vis a vis those of the entire control group of 823 students on the above stated four achievement measures are presented in Table 2.

RESULTS

TABLE 2

Means and Standard Deviations of Male/Female Experimental/Control Group Students of various Achievement scores (N=848)

	Experimental N=25			Control N=823		
	Male N=11	Female N=14	Total N=25	Male N=437	Female N=386	Total N=823
Ach First Test						
Mean	23.91	22.14	22.92	20.41	20.35	20.38
Sd	3.42	4.22	3.92	3.70	3.80	3.74
Ach Sec Test						
Mean	25.91	23.86	24.76	21.70	21.55	21.63
Sd	2.98	2.93	3.07	4.04	4.36	4.19
Ach Fin Test						
Mean	30.82	28.57	29.56	27.53	28.28	27.89
Sd	3.97	2.68	3.43	4.56	4.81	4.69
Ach Total						
Mean	80.64	74.57	77.24	69.64	70.18	69.90
Sd	5.80	7.50	7.34	8.62	9.81	9.19

4.3 ANALYSIS

Since the three achievement test scores and the four attitude subtest scores are not mutually, independent, scores on these seven intercorrelated dependent variables were analysed by treatment by sex (2x2) 2-way multivariate analysis of variance using SPSSx (2nd ed.) on the VAX system at the Yarmouk University Computer Center by the researcher. The MANOVA results are presented in Table 3 through 5. Table 3 shows the multivariate and univariate tests of significance for treatment by sex interaction. Obviously, the results show no sign of interaction effect. Table 4 presents the multivariate and univariate tests of the significance for the main effect sex. Again no sign of sex effect.

RESULTS

TABLE 3

Multivariate and Univariate Tests of Significance for Treatment of Group by Sex

Multivariate Tests of Significance (S = 1, M = 2 1/2, N = 31 1/2)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.06835	.68123	7.00	65.00	.687
Hotellings	.07336	.68123	7.00	65.00	.687
Wilks	.93165	.68123	7.00	65.00	.687

EFFECT .. GROUP BY SEX
Univariate F-tests with (1,71) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FIR	5.98550	1082.22929	5.98550	15.24267	.39268	.533
SEC	2.68787	1319.93372	2.68787	18.59062	.14458	.705
FIN	70.28564	1169.25870	70.28564	16.46843	4.26790	.042
MATER	9.48066	436.82878	9.48066	6.15252	1.54094	.219
TEACHER	.58976	1163.70451	.58976	16.39020	.03598	.850
Q4	.23998	24.76765	.23998	.34884	.68794	.410
Q6	.13424	17.63614	.13424	.24840	.54043	.465

RESULTS

TABLE 4

Multivariate and Univariate tests of significance of the main effect sex

Multivariate Tests of Significance (S = 1, M = 2 1/2, N = 31 1/2)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.10065	1.03923	7.00	65.00	.413
Hotellings	.11192	1.03923	7.00	65.00	.413
Wilks	.89935	1.03923	7.00	65.00	.413

Note .. F statistics are exact.

EFFECT .. SEX
Univariate F-tests with (1,71) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FIR	22.07414	1082.22929	22.07414	15.24267	1.44818	.233
SEC	44.37092	1319.93372	44.37092	18.59062	2.38674	.127
FIN	.49703	1169.25870	.49703	16.46843	.03018	.863
MATER	.11272	436.82878	.11272	6.15252	.01832	.893
TEACHER	37.21388	1163.70451	37.21388	16.39020	2.27050	.136
Q4	.14210	24.76765	.14210	.34884	.40734	.525
Q6	.00076	17.63614	.00076	.24840	.00307	.956

RESULTS

The multivariate and univraiate tests of significance for the main effect treatment are presented in Table 5. The multivariate null hypothesis of no treatment effect is strongly rejected (P LE .002) on all the three statistics - Pillais, Hotelling's, and Wilk's. The univariate tests of significance for all the seven variables show that means of four of them namely, mid-term achievement ($P < .003$), final achievement ($P < .027$), material sub-test of attitude ($P < .003$), and Q4, ($P < .004$) are significantly different between the experimental and control groups at the probability levels ranging from .027 to .003. The null hypothesis of no differeces between the means of treatment and control groups on first tests, and teacher and Q6 subtests of the attitude questionnaire could not be rejected at the prespecified (Alpha = 0.05) level of significance.

RESULTS

TABLE 5

Multivariate and Univariate tests of significance for the main effect treatment

Multivariate Tests of Significance (S = 1, M = 2 1/2, N = 31 1/2)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.28521	3.70517	7.00	65.00	.002
Hotellings	.39902	3.70517	7.00	65.00	.002
Wilks	.71479	3.70517	7.00	65.00	.002

Note .. F statistics are exact.

EFFECT .. GROUP
Univariate F-tests with (1,71) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FIR	58.48504	1082.22929	58.48504	15.24267	3.83693	.054
SEC	174.16879	1319.93372	174.16879	18.59062	9.36864	.003
FIN	83.79893	1169.25870	83.79893	16.46843	5.08846	.027
MATER	56.39364	436.82878	56.39364	6.15252	9.16594	.003
TEACHER	24.15373	1163.70451	24.15373	16.39020	1.47367	.229
Q4	3.03449	24.76765	3.03449	.34884	8.69878	.004
Q6	.00600	17.63614	.00600	.24840	.02415	.877

RESULTS

The total or summative achievement score (the sum of scores on the first, mid-term, and final tests), and the total attitude score were analysed separately by 2-way ANOVA. The ANOVA results on the summative achievement score are presented in Table 6. Since the mumber of subjects in the experimental and control groups is completely unbalanced, the tests of significance in all the analyses were conducted using unique sums of squares. Table 6 clearly shows the highly significant ($P < 0.000$) treatment effect and nonsignificant sex or treatment by sex interaction effects. Table 7 presents the ANOVA results of the total score on the attitude questionnaire. No statistically significant group differences were found, either due to any of the main effects or due to interaction thereof.

TABLE 6

ANOVA of the total achievement score

Tests of Significance for TOT using UNIQUE sums of squares

Source Of Variation	SS	DF	MS	F	Sig. Of F
WITHIN CELLS	70439.59	844	83.46		
GROUP	1415.23	1	1415.23	16.96	.000
SEX	182.66	1	182.66	2.19	.139
GROUP BY SEX	260.76	1	260.76	3.12	.077

TABLE 7

ANOVA of the total Attitude score

Tests of Significance for TOTAL using UNIQUE sums of squares

Source Of Variation	SS	DF	MS	F	Sig. Of F
WITHIN CELLS	2396.47	71	33.75		
GROUP	18.14	1	18.14	.54	.466
SEX	29.32	1	29.32	.87	.354
GROUP BY SEX	15.76	1	15.76	.47	.497

RESULTS

As stated earlier, achievement test data were collected on the total sample of 848 (experimental 25, and control 823), the MANOVA results of the three achievement test scores using the unique sum of squares design are presented in table 8. The treatment by sex interaction and the sex main effect were not significant (Alpha = .05), therefore they are not included in table 8. Only the treatment main effects which were highly significant are presented. As Table 8 shows, the group differences on the first and mid-term test scores are highly significant (p-values 0.001, and 0.000 respectively) but difference on the final test score is not statistically significant at the predetermined (Alpha = .05) level of significance. The interpretation of the results will be discused in chapter V.

RESULTS

TABLE 8

MANOVA of the three Achievement tests treatment of the Main Effect

Multivariate Tests of Significance (S = 1, M = 2 1/2, N = 31 1/2)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.02315	6.65153	3.00	842.00	.000
Hotellings	.02370	6.65153	3.00	842.00	.000
Wilks	.97685	6.65153	3.00	842.00	.000

Note .. F statistics are exact.

EFFECT .. GROUP
Univariate F-tests with (1,844) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FIR	167.37181	11886.26647	167.37181	14.08325	11.88446	.001
SEC	254.17456	14636.01398	254.17456	17.34125	14.65722	.000
FIN	76.37782	18216.55074	76.37782	21.58359	3.53870	.060

CHAPTER 5

INTERPRETATION

5.1 INTERPRETATION

Various Artificial Intelligence tutoring models have been developed during the last few years, and even field tested. The relative efficiency of such models has seldom been empirically investigated. This study intended primarily to investigate the effectiveness of an Intelligent Computer Assisted Instruction tutoring model as compared with the traditional lecture method of teaching university students. Students' achievement and attitude scores were taken as criteria for effectiveness.

Using experimental/control group design setting Sex by Treatment interaction effect, Sex effect, and Treatment (ICAI model) effect hypotheses were tested. The results of multivariate and univariate analyses of variance presented in Chapter IV are interpreted and discussed in the following paragraphs.

INTERPRETATION

As stated in the preceding chapter, two sets of multivariate analyses were conducted: One involved a control sample of 50 subjects randomly selected from 823 students who took the course used in the investigation and were taught by traditional lecture methods, the other analysis included all the 823 as control group. The multivariate analyses included three measures of achievement; first test, mid-term test, and the final test. The sum of these three test scores designated here as total achievement score was taken as the fourth measure of summative assessment of students' achievement in this course. Two separate factorial univariate analyses were conducted, one on achievement total score and one on attitude total score because total scores being the linear sums of other scores could not be legitimately inserted with other variables in the same multivariate analysis.

There is no evidence, whatsoever, of Sex by Treatment interaction effect or of Sex main effect was found in either of the two MANOVAs. In fact, the sizes of the calculated probability levels of multivariate F-values for testing the statistical significance of these hypotheses strongly support the conclusion to uphold the null hypotheses. This study found no evidence of the differential effects of either ICAI or traditional lecture method of teaching on male and female students. There were no differences in the achievement scores of female and male students taught by either method on any of the four measures of achievement.

The primary objective of this investigation, however, was to test the effect of the ICAI method of teaching. The null hypothesis of method effect (no differences in achievement scores of students taught by the two methods) was strongly rejected ($p < .000$) in both the MANOVAs as well as in the ANOVA conducted separately on the total achievement score. Moreover, in the comparisons based upon all the 823 students taken as control, the experimental group (ICAI group) scored significantly higher on the total of three tests (Mean of EXP 77.24 > Mean of CONT 69.90, $P < .000$), the mid-term test (Mean of EXP 24.76 ˊ 21.63, $P < .000$), and on the first test (Mean of EXP 22.92 > Mean of CONT 20.38, $P < .001$). On the final examination although mean score of the experimental group (taught by ICAI method) is higher than that of the control group, the difference did not reach statistical significance tested at alfa level of 0.05.

In the analysis wherein ICAI group was compared with a randomly sampled control of 50 students, the experimental group means on total score, on the mid-term test, and on the final test were statistically significantly higher than those of the control group means on the same tests. On the first test the difference did not reach the prescribed level of significance. It is noted that in one analysis difference on the first test is significant but not on the final, whereas in the other analysis this has been reversed i.e. the difference on the final test is significant but not on the first test.

If course achievement of students measured by achievement tests is admissible evidence of tutoring effectiveness then this study clearly demonstrates the superiority of ICAI tutoring method over the traditional lecture method of teaching at the university level. The findings of this study not only support the conclusion reached by Ruyle (1987), that the expert system proved to be as effective as the human experts at causing learning, they do better. They, perhaps for the first time, demonstrate experimentally the comparative effectiveness of the ICAI tutoring method.

5.1.1 ICAI Effects On Attitude

When it comes to the processes of teaching and learning, students' attitudes are given their due importance as auxiliary factors in facilitating student learning. Though the primary variable of interest was achievement, a 13-item questionaire to gauge students' attitudes or feelings towards a few aspects of teaching methods was also administered to the 25 experimental group students and a random sample of 50 students from the control group.

INTERPRETATION

The questionaire contained seven items concerning teaching effectiveness and related aspects of the instructor such as preparation, presentation, knowledge of the subject matter, responsiveness to students needs, and avilability outside the class. These seven items constituted the teacher factor. Four items related to the subject matter adequacy, appropriateness, quantity, and usefulness constituted the material factor. Question 4 was about the students' feeling about their ability to converse about the computer, and question 6 dealt with the amount of time relative to the amount of material covered.

Like the results of analyses on achievement scores, the tests of hypotheses of Sex by Treatment interaction effect and Sex main effect were not found significant (alpha = .05) on any of the attitudinal variables. The null hypotheses could not be rejected at the predetermined level of statistical significance. However, the multivariate null hypothesis of Treatment main effect was rejected (P < .002).

The results showed no statistically significant (alpha = .05) difference between the means of the two groups on the Teacher Factor, Question 6, and on the total score on all thirteen items. One would expect that the students taught by ICAI method would feel more confident about their ability to converse about the computer. Contrary to expectations the means of the two groups on this item are almost identical. It seems that the one term familiarity of the ICAI students with the computer only enhanced their awareness of how little they know about the computers and this might have dampened their confidence substantially.

On teacher factor, the mean score of the control group is slightly higher but the difference is not significant. However, the statistically highly significant differences in favour of the experimental group on course material factor and relative amount of time scores are very encouraging. It is worth recalling that the course material, contents, objectives, and time was exactly the same for both groups. Yet students taught by the ICAI tutoring method felt more satisfied with the time and subject matter related aspects of the course. These results evidently support the achievement related results and further enhance the confidence in the relative effectiveness of the ICAI tutoring method. It is further noteworthy that out of nine variables studied here , either the differences are significant clearly in favour of the experimental (ICAI) group or they are not significant. Not a single variable yielded significant difference favouring the control group.

The findings of this study, therefore, clearly demonstrate that when the same course contents covering the same course objectives and the same duration of time were taught through ICAI tutorial method as opposed to the traditional lecture method, students obtained statistically significant higher achievement scores measured by the same achievement tests and greater satisfaction with the course contents and time duration measured by the same self report questionaire than did the students taught by the traditional lecture method.

The effectiveness of a tutoring system is universally assessed in terms of the students' achievement test scores, at times, supplemented by their scores on measures of attitudes and feelings. On both counts, the findings of this study speak unequivocably for the effectiveness of the ICAI method.

However this is only one empirical study which has its limitations. Many more experimental studies are needed in this area. The future research should be directed not only to establish the bugfree workability and logical consistency of the ICAI tutoring techniques and systems but also, and more importantly so, the relative cost effectiveness, comparative benefits, and psychological acceptability of such systems.

5.1.2 Future Research

There are several research questions that need to be investigated. The expert system technique of AI used in this study is only one technique. Using heuristics can be a powerful technique in building tutoring systems. A heuristics model should be built and tested. Also, different tutoring or teaching strategies need to be employed and tested. This study used the consultative model of tutoring. Other learning models and strategies such as the "socratic", "learn by doing" and "learn by example" models need to be built into the AI programs and tested.

This study has used one course in computer science for its investigation. The investigation needs to be repeated for other courses of computer science and courses of various subjects other than computer science. Courses that are different in nature should be used, such as computational courses vs general knowledge courses.

A natural language dialogue needs to be included in the tutoring system. The dialogue should be a two way interaction. Several different techniques are available and could be used, implemented and tested. Also it would be interesting to use different languages for the dialogue. For our environment in Jordan, Arabic dialogue could be very useful and might prove very effective.

Knowledge representation is a very important part of the AI techniques for building expert systems. Therefore, experimenting with different knowledge representations such as nets, rules, frames... should be carried out.

INTERPRETATION

A more sophisticated method for collecting, monitoring and evaluating the students' progress must be built into the ICAI system and tested. Information can be collected on the student as he or she interacts with the system. Also, automatic testing modules should be built into the program.

At the end of this study one thing can be said for sure. This study has raised more questions in the mind of this researcher than it answered. I hope to continue this investigation and hope that others can and will continue and build on this study.

5.1.3 Potential Applications And Recommendations

P; Jordan has committed itself to modernize administrative methods and procedures of its institutions at all levels. It also has made a commitment to upgrade the quality of elementary, secondary and higher education. Realizing that computers are the tools for fast accurate and timely information processing, the government of Jordan has encouraged the use of computers in its departments, industry and education. A pilot project of introducing computers into junior and high schools is already under way. Computer usage is spreading fast in Jordan society. This fast expansion needs well trained people. Some use of CAI software is necessary to accomodate the training needs for such expansion. The use of ICAI techniques to build courses to run on micro-computers is very economical." Expert Systems

Shells" are very inexpensive. The bulk of the work would be in building the "Knowledge bases" of the subject matter. A nucleus of trained people could be created in Jordan for developing the ICAI systems for use by Jordanian students at all levels. This is very viable and very inexpensive and effective as was shown by this research.

There are four major universities in Jordan. Two of them are acquiring computer installations of major proportions. The others are in the middle of planning major computer procurements. These computers will be used for teaching. ICAI software will be needed to provide course material to help the teaching process. Plans are already underway for acquisition of CAI systems. A select group of computer scientists, engineers and educationists can build those systems right here in Jordan. The material or "Knowledage base" could be tailored for Jordanian Students. The effectiveness of such techniques have already shown encouraging results. Self teaching, "learning by doing" courses can play a major part in education in Jordan.

Jordan prides itself on the medical achievements it has made lately. Hospitals are looking to advance further these achievements by using AI techniques for medical consultations and diagnosis. AI has shown by the "MYCIN" research that computer programs can outperform experienced medical doctors in diagnosis and at least can help others in the diagnosis process. ICAI Systems can be used to train doctors in making diagnoses at a low cost. Again this research can be used as a model or a first step towards the applications of ICAI Systems in medicine.

Jordan, though is a center for providing trained personnel to the other Arab Countries, still needs a trained cadre to train and prepare others professionally. Technical staff is still at a premium. ICAI systems can be used to train the technical personnel required such as electricians, machine operators, maintenance personnel, welders and other skilled technicians.

We can see from the above the tremendous possibilities and implications of this study. I recommend the formation of a technical team based in one of Jordan's Universities to carry out a development project of ICAI systems that can be used at the high school and university levels. Also I would suggest that the Engineers Association in Jordan look into the possibility of creating a training center based on ICAI for technical staff training. Also hospitals in cooperation with university researchers can start a program of ICAI for doctor's training. Finally I urge the Ministry of Education to look into ICAI techniques for using ICAI systems in high school education.

5.1.4 Social Implications

If ICAI systems can perform better than traditional methods of teaching , as this study shows, then what does this mean to the traditional classroom teacher and the teaching profession?. In order to answer the first part of this question, one must look at computer science education and department staffing in Jordanian universities. No one will disagree that there exists an acute shortage of qualified computer science teachers. The use of ICAI could very well satisfy part of this shortage. Also, high school teachers in Jordan have not had the training in computer science to cope with the new national objective of introducing computer education in elementary and high schools.

The other side of the question has to do with the effect on the teaching profession? I personally think that the teaching profession must adapt this new technology and make use of it. Will making use of computers as teachers dehuminize the teaching profession? Certainly the computer is not human and some aspects of the absence of the teacher from the classroom is somewhat strange and may make some people insecure. I suggest that the computer and the teacher team up together thus freeing each to do what he/she/it can do best. In a sense the computer can give the teacher freedom from the drudgery of routine teaching tasks such as making up questions ,drilling the student by presenting problems, constructing and correcting examinations. I believe educators have a golden oppurtunity in a new technology where the teacher can be the "master" and the ICAI system, the helper. It may do to the educator what the tractor did to the farmer. I do hope that educators in Jordan and everywhere else will use ICAI systems.

APPENDIX A

KNOWLEDGE BASE

UNIT 1

1. If its size is bulky

   and it has large vacuum tubes

   and it requires lot of air conditioning

   and it has demanded high maint. and repair

   and it is producing lot of heat

   Then Definition is First Generation Computer

2. If computer does not have large vacuum tubes

   and it has tiny transistors

   and it uses less electric power

   and it has offered greater reliability

   and its size is not bulky

   Then Definition is Second Generation Computer

3. If its components are reduced in size

   and its components are advamced miniaturized and refined and its facilities have included new and fast I/O method

and its facilities have long range data transmission

and its facilities have displays on video tubes (CRTS)

Then Definition is Third Generation Computer

4. If technological changes are in operating system and multiprograming and technological changes are in multiprogramming and timesharing and technological changes are in data communications and hardware miniature

and new concept is of virtual memory and virtual devices

Then Definition is Fourth Generation Computer

5. If it is a small desktop computer

and it has a CPU

and it has at least 4KB of main memory

Then Definition is minicomputer

6. If it is defined as a miniature computer

and its chip is made of solid state IC

and it has characteristics of larger systems

Then Definition is microcomputer

7. If it is a planned operations on data

and these operations are to achieve desired results

Then Definition is data processing

KNOWLEDGE BASE

8. If it is a process of assembling instructions
and this process is to assemble in logical sequence
and this sequence is to be understood by the computer
Then definition is programming

9. If it is a set of instructions
and it is fed into the computer
and it is to accomplish a particular job
Then Definition is the program

10. If it is collection of physical equipment
and this equipment is the devices of computer
and this equipment is including peripheral devices
Then Definition is hardware

11. If it is a set of program and procedures
and it has associated documentation
and this documentation is concerned with operation of
Data Processing systems
Then definition is software

12. If it is to accept data for processing
and it is to make results available
and these results are sent to output devices
Then definition is CPU

13. If it is to manage I/O devices
and CPU is sending I/O request to it
and it is interface between I/O devicess and CPU

Then Definition is channels.

UNIT 2

1. If it is circuitry to do arithmetic operations
and it is circuitry to do logical operations
and it is a part of CPU
Then Definition is ALU Arithmetic and Logical Unit

2. If it has to decode instructions of execution
and it is coordinating all operations
and it is sending commands to ALU
and it is sending commands to IO devices
Then Definition is Control Unit (CU)

3. If it has Arithmetic and logic unit
and it has Control Unit
and it supervises and controls DP components
and it is Known as heart of DP system
Then Definition is Central Processing Unit (CPU)

4. If it is Known as core storage
and Data for instant processing is placed in it
and each unit is addressable
and information stored is only in binary form
Then Definition is Main storage

5. If it is storing information temporarily
   and it is receiving information from other areas
   and it transfers information to other areas
   and its length is not more than one word
   Then Definition is register

6. If it has magnetic element
   and data is recorded in tracks on it
   and recorded data is moved past recording heads
   and it is Known as disk, drum or tape
   Then Definition is Magnetic storage devices

7. If its physical construction is similar to main storage
   and user is capable to write information on it
   and user is capable to read information from it
   Then Definition is Random Access Memory (RAM)

8. If its physical construction is similar to main storage
   and user is not capable to write information on it
   and user is capable to read information from it
   and some software is stored on it
   Then Definition is Read Only Memory (ROM)

UNIT 3

1. If it is used primarily for storage
   and it is resembling a 45-RPM record
   and it is low cost storage device
   and it is compact and flexible

Then Definition is floppy disk

2. If it is used on-line
   and it is for direct communications with computer
   and it is to replace hard copy output
   and it is used for on-line inquiry
   Then definition is display terminals (CRT)

3. If its character set is machine recognizable
   and its output is useful to people and machines
   and its extensive use is in banking operations
   Then definition is Magnetic Ink Character Reader

4. If it is either zero or one
   and it is abbreviation of binary digit
   and this term is used in computer terminology
   Then definition is bit

5. If its length is 8 bits
   and it is to accomodate one character
   and it is made up of four zone bits
   and it is made up of four numeric bits
   Then definition is byte

6. If it is number of digits in a number-system
   Then definition is base (Radix)

7. If it is known as number-system
   and it has only 2 digits (0 and 1)
   Then definition is binary-number-system

8. If it is known as number-system
   and it has 8 digits (0,1,2...,7)
   and its base is 8
   Then definition is Octal Number-System

9. If it is known as number-system
   and it has 16 digits (0,1,2...9,A,B...F)
   and its base is 16
   Then definition is Hexadecimal Number-System

10. If its length is 4 bits
    and these 4 bits are representing decimal digit
    and representation is in binary
    Then definition is BCD (Binary Coded Decimal)

11. If its length is 8 bits
    and it is to represent all characters
    and it is also known as byte of data
    and its abbreviated name is for Extion
    of Binary Coded Decimal
    Then definition is EBCDIC

12. If its configuration has used seven bits
    and its eighth bit is for parity check
    and it is to represent all characters

and this code result is an attempt to simplify communications and this code result is an attempt to standardize communications
Then definition is ASCII

UNIT 4

1. If it is representing an event or fact
   and this is real world fact
   and it is represented as string of characters
   Then definition is Data

2. If it is obtained by processing data
   and it is result of collecting data
   and it is result of analysis of data
   and it is result of summarizing data
   Then definition is Information

3. If it is a piece of data
   and it is referenced as element in processing
   Then definition is field

4. If it is a set of pieces of data (fields)
   and these pieces are related with each other
   and these pieces are combined to represt an entity
   Then definition is record

5. If it is a set of records
   and these records are stored on storage device
   and these records are kept for retrieval
   Then definition is file

6. If it is a collection of data fundamentals
   and this collection is belonging to an enterprise
   and this collection is used mostly for queries
   or if it is a collection of interelated files
   Then definition is Data Base (DB)

7. If it is a computerized system
   and this system has numerous components
   and its purpose is implementation of large scale DB
   and its purpose is for management and protection of LSDB
   Then definition is data base management system

8. If this is a process of execution
   and this process is executing programs serially
   or if this process is sequential input of programs/data
   or if execution of one program is completed before next program
   Then definition is batch processing

9. If this is a mode of computer system
and in this mode input data is entered directly from origin
and output data is transmited directly where used
Then definition is on-line system

10. If this is a computer application
and If response to input is so fast
it offsets next input
Then definition is real-time

11. If this is a computer application
and this computer application is
allowing many users same time access
and many users are allowed to execute programs
and these users are allowed to interact during execution
Then definition is time-sharing

UNIT 5

1. If it is a string of binary digits
and this string is conversion of another bit string
and each digit position is reversed i.e 0 by 1 and 1 by 0
and one is added to this string
Then definition is two's complement

KNOWLEDGE BASE

2. If it is a string of binary digits

   and this string is conversion of another bit string

   and each digit position is reversed i.e 0 by 1 and 1 by 0

   and one is not added to this string

   Then definition is one's complement

3. If it is used for storage

   and it is extension of main memory

   and all information to and from

   it has to pass thru main memory

   Then definition is secondary storage

4. If it is used for storage

   and it is in the form of cartridge/cassette

   and magnetic material is coated on it for recording

   and it is sequential in nature

   Then definition is tape

5. If it is a hardware device

   and it is used to read/write (R/W)

   data on Magnetic tapes

   Then definition is tape drive (tape unit)

6. If it is a hardware device

   and it is used to R/W data on disks

   Then definition is Disk drive (Disk unit)

KNOWLEDGE BASE

7. If it is thin metallic platter
   and it is resembling a phonogram
   and it is coated on both sides with
   iron oxide recording material
   and several platters are mounted
   on a vertical shaft
   and it has concentric circular tracks
   and read/write heads are positioned
   by access arm in it
   Then definition is Disk (Magnetic Disk)

UNIT 6

1. If it is used to communicate with computer
   and it is used to convey instructions
   and it is termed as a language
   Then definition is programming language

2. If it is a programming language
   and it is used for business applications
   and it is abbreviated from
   common business oriented language
   Then definition is COBOL

3. If it is a programming language
   and it is used in scientific applications
   and it is abbreviated from FORMULA Translation
   Then definition is FORTRAN

4. If it is a programming language
   and it is used primarily for all purpose
   and it is abbreviated from
   beginners all purpose symbolic instructions code
   Then definition is BASIC

5. If it is a programming language
   and it is a low level language
   and it is near to machine language
   Then definition is ASSEMBLER

6. If it is a programming language
   and it is used to generate reports
   and it is abbreviated from report program generate
   Then definition is RPG (Report Program Generator)

7. If it is a programming language
   and it is used for list processing
   and its name is of an early computer scientist
   Then definition is PASCAL

8. If it is a programming language
   and it is used in scientific/business applications
   and it is abbreviated from programming language I
   Then definition is PL/I (Programming language I)

UNIT 7

KNOWLEDGE BASE

1. If the system has CPU

   and the system has main memory

   and the system has input devices

   and the system has output devices

   Then the machine is computer

   Else the machine is not computer

2. If the Unit has ALU

   and the Unit has control unit

   and the unit has flip flop registers

   then the system has CPU

   Else the system does not have CPU

3. If the unit has an I/O link with main memory

   and the unit has ability to fetch instructions

   and the unit has ability to decode instructions

   and the unit is able to command ALU

   Then the unit has control unit

   Else the unit does not have control unit

4. If the unit has an I/O link with main memory

   and the unit is able to fetch and store data

   and the unit is able to perform arithmetic op

   and the unit is able to perform logical op

   and the unit has accumulators

   Then the unit has ALU

   Else the unit does not have ALU

5. If it is small unit of volatile memory
   and information is stored temporarily
   and capacity of one unit is 32 bits or four bytes
   and these units are usually 16 in number
   Then the unit has flip flop registers
   Else the unit does not have flip flop registers

6. If the unit has cores
   and the unit is able to store information
   and it is known as RAM
   and it has I/O link with CPU
   and it has input link with input devices
   and it has output link with output devices
   Then the system has main memory
   Else the system does not have main memory

7. If the system has terminal screen
   or if the system has card reader
   or if the system has disk drives
   or if the system has drum units
   or if the system has floppy diskette
   or if the system has tape drives
   Then the system has input devices
   Else the system does not have input devices

8. If the system has terminal screen
   or if the system has printer
   or if the system has disk drives

or if the system has drum units

or if the system has floppy diskette

or if the system has tape drives

or if the system has card punch device

Then the system has output devices

Else the system does not have output devices

UNIT 8

1. If it is a compter application program

   or if it is a computer control program

   and it is stored in main memory

   or if it is stored on storage device

   Then program is computer software

   Else program is not computer software

2. If it is a set of instructions

   and it is written by programmer

   and it is in source code

   and it is used to generate report

   or if it is used to create a file

   or if it is used to update a file

   or if it is used to retrieve information

   Then it is a computer application program

   Else it is not computer application program

KNOWLEDGE BASE

3. If it is a set of instructions
   and it is supplied by manufacturer
   and it is used to control computer
   or if it is to organize devices or files
   and it is in object code
   Then it is a computer control program
   Else it is not computer control program

4. If it is in human oriented language
   or if it is written in COBOL or FORTRAN
   or it is written in PL/I or PASCAL
   or it is written in ASSEMBLER
   Then it is in source code

5. If it is in binary form only
   and it is not in human oriented language
   Then it is in object code

6. If it is English like language
   or if it is easily understood by humans
   Then it is human oriented language
   Else it is not in human oriented language

APPENDIX B

REFERENCES

1. Abelson, R. P., 1979, Differences between belief and knowledge systems, Cognitive Science 3:355-366.

2. Abelson, H., and diSessa, A., 1981, Turtle geometry: The computer as a medium for exploring mathematics, Cambridge, Mass., MIT Press.

3. Anderson, J. R., 1976, Language, memory, and thought, Hillsdale, N.J., Lawrence, Erlbaum.

4. Anderson, J. R., and Bower, G. H., 1973, Human associative memory, Washington, D.C., Winston.

5. Atkinson, R. C., and Wilson, H.A.(Eds.), 1969, Computer-assisted-instruction, New York, Academic Press.

6. Backus, J. W., 1958, Automatic programming-properties and performance of FORTRAN systems I and II, Proceedings of the Symposium on the Mechanisation of Thought Processes, Teddington, Middlesex, England, National Physical Laboratory.

REFERENCES

7. Barr, A., Beard, M., and Atkinson, R.C., 1975, A rational and description of a CAI program to teach the BASIC programming language, Instructional Science 4:1-31.

8. Barr, A., Beard, M., and Atkinson, R.C., 1976, The computer as a tutorial laboratory: The Stanford BIP project, International Journal of Man-Machine Studies 8:567-596.

9. Barr, A., and Atkinson, R. C., 1977, Adaptive instructional strategies, In H. Spada and W. F. Kempf (Eds.), Structural models of thinking and learning, Bern: Hans Huber.

10. Barr, A., Feigenbaum, E. A., and Cohen, P. R., 1982, The Handbook of Artificial Intelligence, 3 vols., W. Kaufman, Los Altos, California.

11. Biermann, A. W., 1976, Approaches to automatic programming In M. Rubinoff Press, 1-63.

12. Boden, Margaret A., Artificial Intelligence and Natural Man, Basic Books, New York, 1977.

13. Booth, A. D. (Ed.), 1967, Machine translation, Amsterdam, North-Holland.

14. Boyer, R. S., and Moore, J. S., 1979, A computational logic, New York, Academic Press.

REFERENCES

15. Brown, G. P., 1977, A framework for processing dialogue, Rep. No. TR-182, Leboratory for Computer Science, Massachusetts Institute of Technology.

16. Brown, J. S., 1975, Uses of AI and advanced computer technology in education, Bolt, Beranek, and Newman, Cambridge.

17. Brown, J. S., 1977, Uses of artificial intelligence and advanced computer technology in education, In R. J. Seidel and M. Rubin (Eds.), Computers and communications: Implications for education, New York, Academic Press, 253-270.

18. Brown, J.S., Burton, R. R., and Bell, A. G., 1974, SOPHIE: A sophisticated instructional environment for teaching electronic troubleshooting (an example of AI in CAI) BBN Rep. No. 2790, Bolt Beranek and Newman, Inc., Cambridge, Mass.

19. Brown, J. S., Burton, R. R., and Larkin, K. M., 1977, Representing and using procedural bugs for educational purposes, Proceedings: 1977 Annual Confernce, ACM, Seattle, 247-255.

20. Brown, J. S., and Goldstein, I.P., 1977, Computers in a learning society. Testimony for the House Science and Technology Subcommittee on Domestic and International Planning, Analysis, and Cooperation.

REFERENCES

21. Brown, J. S., and Burton, R. R. 1978, Multiple representations of knowledge for tutorial reasoning, In D. G. Bobrow and A. Collins (Eds.), Representation and understanding: Studies in cognitive, New York, Academic Press, 311-349.

22. Brown, J. S., Collins, A., and Harris, G., 1978, Artificial inteligence and learning strategies, In H. O'Neil (Ed.), Learning strategies, New York, Academic Press, 107-140.

23. Buchanan, B. G., Sutherland, G. L., and Feigenbaum, E. A., 1969, Heuristic DENDRAL: A program for generating explanatory hypotheses in organic chemistry, In B. Meltzer and D. Michie (Eds.), Machine Intelligence 4, Edinburgh, Edinburgh University Press, 209-254.

24. Buchanan. B. G., Mitchell, T. M., Smith, R. G., and Johnson, C. R. Jr., 1977, Models of learning systems, In J. Belzer, A. G. Holzman, and A. kent (Eds.), Encyclopedia of computer science and technology (Vol.11), New York, Marcel Dekker, 24-51.

25. Carbonell, J. R., 1970, Mixed-initiative man-computer instructional dialogues, BBN Rep. No. 1971, Bolt Beranek and Newman, Inc., Cambridge, Mass.

REFERENCES

26. Carr, B., and Goldstein, I., 1977, Overlays: A theory of modeling for computer aided instruction, AI Memo 406, AI Laboratory, Massachusetts Institute of Technology.

27. Clancey, W. J., 1979, Transfer of rule-based expertise through a tutorial dialogue. Rep. No. Science Dept., Stanford University. (Doctoral dissertation.)

28. Clancey, W. J., and Letsinger, R., 1982, NEOMYCIN; Reconfiguring a rule-based expert system for application to teaching, IJCAI 7,829-836.

29. Collins, A. M., 1976, Processes in acquiring knowledge, In R. C. Anderson, R. J. Spiro, and W. E. Montague (Eds.), Schooling and the acquisition of knowledge, Hillsdale, N. J., Lawrence Erlbaum, 339-363.

30. Collins, A. M., 1978a, Fragments of a theory of human plausible reasoning TINLAP-2, 194-201.

31. Collins, A. M., 1978b, Reasoning form incomplete knowledge, In D. G. Bobrow and A. Collins (Eds.), Representation and understanding: Studies in cognitive science, New York, Academic Press, 383-415.

32. Crowder, N. A., 1962, Intrinsic and extrinsic programming, In J. E. Coulson (Ed.), Proceedings of the Conference on Application of Digital Computers to Automated Instruction, New York, Wiley, 58-65.

REFERENCES

33. Davis, R., 1976, Applications of meta-level knowledge to the construction, maintenance, and use of large knowledge bases, Memo AIM-283, AI Laboratory, and Rep. No. STAN-CS-76-552, Computer Science Dept., Stanford University.

34. Feigenbaum, and J. Feldman (Eds.), 1963, Computers and thought, New York, McGraw-Hill, 71-105.

35. Feigenbaum, E. A., and Simon H. A., 1964, A theory of the serial position effect, British Journal of Psychology 35:307-320.

36. Fischer, G., Brown, J. S., and Burton, R. R., 1978, Aspects of a theory of simplification, debugging, and coaching, Proceedings of the Second Annual Conference of the Canadian Society for Computational Intelligence.

37. Fischer, K. W., 1980, A theory of cognitive development: The Control and Construction of Hierarchies of Skills, Psychological Reveiw, 87:477-531.

38. Fitz-Gibbon, C. T., and Morris, L.L., 1978, How to design a program evaluation, Beverly Hills, Sage Publication.

39. Goldberg, A., 1973, Computer-assisted instruction: The application of theorem proving to adaptive response analysis, Tech. Rep. 203, Institute for Mathematical Studies in the Social Sciences, Stanford University.

REFERENCES

40. Goldstein, I., 1977, The computer as coach: An athletic paradigm for intellectual education, AI Memo 389, AI Laboratory, Massachusetts Institute of Technology.

41. Goldstein, I., 1979, The genetic epistemology of rule systems, International Journal of Man-Machine Studies 11:51-77.

42. Hayes-Roth, B., 1980, Human planning processes, Rep. No. R-2670-ONR, Rand Corp., Santa Monica, Calif.

43. Hayes-Roth, Frederick, Waterman, D. A., and Lenat D. B., (editors), 1983. Building expert systems, Addison-Wesley, Reading, MA.

44. Heidorn, G. E., 1977, The end of the user programmer? The Software Revolution, infotech State of the Art Conference, Copenhagen, Denmark.

45. Herzberg, F., 1966, Work and the nature of man, World publishing Co., Inc.

46. Howe, J. A. M., 1973, Individualizing computer-assisted instruction, In A. Elithorn and D. Jones (Eds.), Artificial and Human Thinking, Amsterdam, Elsevier, 94-101.

47. Jacquez, J. A. (Ed.), 1964, The diagnostic process, Proceedings of a conference sponsored by the Biomedical Data Processing Training Program, University of Michigan

Medical School, Ann Arbor.

48. Koffman, E. B., and Blount, S. E., 1975, Artificial Intelligence and Automatic Programming in CAI, Artificial Intelligence 6:215-234.

49. Laubsch, J. H., 1975, Some thoughts about representing knowledge in instructional systems, IJCAI 4,122-125.

50. Ledley, R., and Lusted, L., 1959, Reasoning foundations of medical diagnosis, Science 130:9-21.

51. Liao, S., 1978, Learner directed instruction: Additional Evidences, The Accounting Review, 53:155-161.

52. Lippitt, G, 1983, Learning: Doing what can come naturally, Training and Development Journal, August, 70-37.

53. Maslow, A. H., 1970, Motivation and personality, 2nd. Edition, Harper and Row Publishers, New York, NY.

54. McCarthy, J., 1958, Programs with common sense, In Proceedings of the Symposium on the Mechanization of Thought Processes, National Physical Laboratory 1:77-84, (Reprinted in M. L. Minsky (Ed.), 1968, Semantic information processing, Cambridge, Mass., MIT Press, 403-409.)

REFERENCES

55. McDermott, D., and Doyle, J., 1980, Non-monotonic logic I, Artificial Intelligence 13:41-72.

56. Michie, D., 1974, On machine intelligence, John Wiley and Sons, New York.

57. Miller, M. L., and Goldstein, I., 1977, Problem solving grammars as formal tools for intelligent CAI, Proceedings: 1977 Annual Conference, ACM, Seattle.

58. Minsky, M., 1975, A framework for representing knowledge, In P. Winston (Ed.), The psychology of computer vision, New York, McGraw-Hill, 211-277.

59. Moses, J., 1967, Symbolic Integration, Ph.D. Thesis, Massachusetts Institute of Technology, Cambridge, MA.

60. Mostow, D. J., 1981, Mechanical transformation of task heuristics into operational procedures, Rep. No. CS-81-113, Computer Science Dept., Carnegie-Mellon University, (Doctoral dissertation.).

61. Mostow, D. J., and Hayes-Roth, F., 1979, Machine-aided heuristic programming: Aparadigm for knowledge engineering, Rep. No. Rand N-1007-NSF, Rand Corp., Santa Monica, Calif.

62. Newell, A., and Simon, H. A., 1972, Human problem solving, Englewood Cliffs, N. J., Prentice-Hall.

REFERENCES

63. Nilsson, N. J., 1974, Artificial intelligence, In J. L. Rosenfeld (Ed.), Infromation processing 74: Proceedings IFIP Congress 1974, Amsterdam, North- Holland, 778-801.

64. Norman, D. A., Gentner, D. R., and Stevens, A. L., 1976, Comments on learning schemata and memory representation, In D. Klahr (Ed.), Cognition and instruction, Hillsdale, N. J., Lawrence Erlbaum, 177-196.

65. Owens, R. G., 1981, Organizational Behavior in Education, 2nd Edition, Prentice-Hall, Inc., Englewood Cliffs, N.J.

66. Piaget, J. (D. Coltman, Trans.), 1970, Science of education and the psychology of the child, New York, Viking.

67. Piaget, J., 1981, The paychology of intelligence, Littlefield, Adams and Co., Ottowa, New Jersey.

68. Piaget, J., and Inhelder, B. (H.Weaver, Trans.), 1969, The psychology of the child, New York, Basic Books.

69. Porter, Lyman W. and Lawler, Edward E., 1968, Managerial Attitudes and Performance, Richard D. Irwin, Inc., Homewood, IL.

REFERENCES

70. Quillian, M. R., 1968, Semantic Memory, In M. Minsky (Ed.), Semantic information processing, Cambridge, Mass., MIT Press, 216-270.

71. Roberts, L., 1965, Machine perception of three-dimensional solids, In J. Tippett (Ed.), Optical and electro-optical information processing, Cambridge, Mass., MIT Press, 159-197.

72. Robinson, J. A., 1965a, A Machine-Oriented Logic Based on the Resolution principle, Journal of the Association for Computing Machinery, vol. 12, no. 1.

73. Robinson, J. A., 1965b, A machine-oriented logic based on the resolution principle, J. ACM 12:23-41.

74. Ruyle, Kim E., 1987, Effectiveness of an expert system for teaching technical subject matter (Dissertation), Oregon State University, Eugene, Oregon.

75. Samuel, A. L., 1959, Some studies in machine learning using the game of checkers, IBM J. Research and Development 3:210-229.

76. Self, J. A., 1974, Student models in computer-aided instruction, International Journal of Man-Machine Studies 6:261-276.

REFERENCES

77. Shortliffe, E. H., 1976. Computer-based medical consultations: MYCIN, New York, American Elsevier.

78. Simon, H. A., 1969, Sciences of the artificial, Cambridge, Mass., MIT Press.

79. Smith, D. H., and Carhart, R. E., 1976, Applications of artificial intelligence for chemical inference XXIV, Stuctural isomerism of mono- and sesquiterpenoid skeleton 1,2-, Tetrahedron 32:2513.

80. Stevens, A. L., and Collins, A., 1978, Multiple conceptual models of a complex system, BBN Rep. No. 3923, Bolt Beranek and Newman, Inc., Cambridge, Mass.

81. Stevens, A. L., Collins, A.,and Goldin, S., 1978, Diagnosing student's misconceptions in causal models, BBN Rep. No. 3786, Bolt Beranek and Newman, Inc., Cambridge, Mass.

82. Vroom, V. H., 1964, Work and motivation, John wiley and Sons, Inc., New York, NY.

83. Vygotsky, Lem Semenovich, 1962, Thought and Language, The M.I.T. Press, Cambridge, MA.

84. Weizenbaum, J., 1966, ELIZA, A computer program for the study of natural language communication between man and machine, CACM 9:36-45.

REFERENCES

85. Weizenbaum, J., 1976, Computer power and human reason, W. H. Freeman, San Francisco, CA.

86. Wilson, D. A., 1978, On the pedagogy of financial acconting, The Accounting Review, 396-401.

87. Winston, P. H., 1977., Artificial intelligence, Reading, Mass., Addison Wesley.

88. Winston, P. H., and Horn, B. K. P., 1981, LISP. Reading, Mass., Addison Wesley.