DEVELOPMENTS IN COMPUTER ASSISTED INSTRUCTION AND AUTHORING SYSTEMS

BY

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NOMENCLATURE

Abbreviation	**Expansion / Description**
AOS	Automated Teaching System (USSR)
BIA	Basic Intelligence Aptitude
BIP	Basic Instructional Program
CAI	Computer Aided Instruction, Computer Assisted Instruction
CERL	Computer based Education Research Laboratory
CONDUIT	Consortium of Oregon, North Carolina, and Dartmouth, and Universities of Iowa and Texas
CRT	Cathode Ray Tube
CTBS	Cognitive Test for Basic Skills
ETS	Educational Testing services
IBM	International Business Machines
ICAL	Intelligent Computer Aided Instruction
ICS	Intelligent Computer Systems
IIAS	Interactive Instructional Authoring System
MECC	Minnesota Educational Computing Consortium,
MEP	Micro Electronics Program
MSC	Manpower Services Commission
NDPCAL	National Development Program in Computer Assisted Learning
PLATO	Programmed Logic for Automatic Teaching Operations
RHEIO	Rural Highlands Educational Improvement Organization
SMDP	Scottish Micro-electronics Development Program
TICCIT	Time shared Interactive Computer Controlled Information Television system

Chapter 1

Introduction

Technological advance made available a wide array of wondrous gadgetry from electric bulbs to computers. Now that cost is not a major factor in getting hands on some sophisticated computer hardware and multimedia technology, it is time to reexamine the role of computer technology in the classrooms.

The aim of this thesis is to examine Computer Aided Instruction (CAI) systems closely and recap the success stories of their exploits. At the same time try to understand their frustrations and failures and the underlying misconceptions, errors and oversights. As pioneers envisioned, does computer technology have the ability or potential to take over all the responsibilities of a teacher of a traditional or modern educational institution?

In order to accomplish this goal, it is necessary to review the earlier work in this field. This review starts with the pioneering work of Dr. Sidney L. Pressey (1929) and other post World War II efforts in programmed instruction and development of teaching machines (Chapter 2). The objective of the review of programmed instruction and teaching machines is to understand the vision and the theory underlying the idea of using man-made machines to teach.

In chapters three, four, and five, several computer aided instruction projects and experiments are reviewed. These projects, experiments, and case studies are studied to grasp the assumptions, expectations, aspirations, and their limitations.

It is more appropriate to examine the learning process from the perspective of external and internal conditions that caused learning. The author believes that the roots of the learning process lie in the motivation to solve a problem or a series of problems. The author likes to distinguish that reading, listening and other similar activities produce information. The understanding of information and its application causes knowledge. The application of knowledge to solve a real world problem causes learning.

A brief review of the various prominent learning theories is provided in appendix A. The objective of appendix A is to give an executive review of various learning theories and expound in some of the concepts in greater detail for the benefit of the curious reader. An extensive bibliography is added for any in-depth study into the learning theories.

In chapter six a meaningful computer assisted individualized instruction model is developed based on the traditional classroom instruction procedures and learning theories. This model is used to compare, understand, and contrast the learning accomplishments, failures, and other significant learning behaviors of various CAI systems studied in the earlier chapters of this thesis.

Chapter seven uses the computer learning model to discuss the effectiveness of the CAI programs and systems reviewed in the thesis. This model is also used to identify the deficiencies of these CAI programs and systems. Chapter eight summarizes the efforts of this thesis.

Chapter 2

Programmed Instruction

Programmed instruction is a learning experience in which a program takes the place of a tutor and leads the student through a set of pre-specified behaviors. The program can be in the form of a teaching machine, a programmed text book, or a computer simulating a teaching machine. The popular types of programmed instruction are Skinnerian type programs (constructed response programs) and Crowder type programs (multiple choice programs). A Skinnerian type of programmed instruction uses an ordered sequence of stimulus items, questions or statements. The student is asked to respond to each of these stimulus items. The steps between the items are very small and the student is reinforced by immediate knowledge of results. A Crowder type of programmed instruction uses the response as a test of whether the student has grasped an essential point of the passage and provides for frequent errors by explaining why an erroneous response is wrong.

Generally, all programmed instruction types depend on some type of psychological conditioning such as Skinner's operand conditioning, Pavlov's classical conditioning, Guthrie's contingency learning or some combination of them. Before a program can be designed, it is necessary to specify the desired end product very clearly. The results of programmed instruction also can be accomplished with the help of a skillfully planned and organized tutorial session.

Programmed instruction and teaching machines attracted a lot of interest in the mid 1950s. Programmed instruction methods incorporate a collection of psychologically sound teaching principles leading to a new teaching and learning process. Pioneer work in the field of the teaching machines is accredited to Dr. Sidney L. Pressey. Pressey's first published reference to a teaching machine was in *School and Society* published in 1926.

This teaching machine was developed from a self recording, multiple-choice reaction apparatus invented in 1915 (Pressey, 1926).

Most of Pressey's work used mechanical principles and multiple choice programs. Mechanical tutors developed by the US Navy during World War 11 (Fry, 1963), the subject matter trainers developed by the US Air Force in 1955(Briggs, 1958), the video-sonic teaching machine of the Hughes Aircraft Company (Fry, 1963) and several other devices and teaching programs are based on multiple choice program. The Hively Machine and the Didak 101 Pre-Verbal Machine which are used for discrimination training are also based on multiple choice program (Fry, 1963).

Pressey, in the 1920's, demonstrated the effectiveness of programmed instruction (Pressey, 1926). Pressey used his punch board and gave students immediate knowledge of the results. Several military devices constructed in the 1940's and 50's demonstrated the learning value of overt responses to a series of logically oriented stimuli followed by knowledge of the result. Student workbooks are made on the assumption that constructed responses have a special value in learning. Skinner's contribution to this series of developments was to demonstrate a simple, highly usable, verbal learning device, based on operand conditioning theory, which has the ability to make maximum use of some weak elementary reinforcers.

Much of the post World War II research and writing came from Dr. B. F. Skinner at Harvard University. Skinner used teaching machines as a technique for applying his principles of learning. He viewed the teaching machine as a solution to the problems of the traditional classroom environment. He found that the exercise of control over behavior was best achieved by careful and selective reinforcement of knowledge. Skinner's principle of reinforcement is in terms of rewarding by permitting the student to learn the validity of the answer as soon as he has given it. The principle of reconstruction was preferred to recognition, hence a construction response is preferred to a multiple choice program. Thus, a program or teaching machine is a private tutor designed to induce a sustained activity, to ascertain a clear understanding of various steps, to control the sequence of events, to provide clues to maintain low error rate and to provide immediate reinforcement in form of reward.

Some of the constructed response teaching machines are the slider machine (developed by Skinner in 1954), the disk type machine, the typewriter input computing machine (an electronic computer with the facility of a type written response), audio visual combination devices, mimeographed sheets, and program books (Fry, 1963).

Most of the programs developed in the 1960's were based on the Skinnerian method of programmed instruction. Based on the first programs and writings about those programs, there were indications that Skinnerian type of programs become rigid and hardened into fixed and mechanical procedures lacking flexibility. Teaching programs have been used successfully in all levels of the educational system and at all levels of ability to teach a great variety of subject matter, verbal, and non-verbal skills. However the effectiveness of these teaching programs is not clear. How they teach and what combination of characteristics that make them teach well is still in doubt (Blomeyer & Martin, 1991).

There is little evidence to prove that the constructed response, which is an important part of Skinner's theory, is any better than a selected response or a sub-vocal response or no response at all. Several experiments using simple reading methods, but omitting the confirmation, have accomplished as much learning as by the usual process of stimulus, response, and confirmation. A few experiments even tried scrambling the order of the program. However there were no significant differences in the results between the learning from the scrambled and the ordered programs. This result may be due to the way the research was done (Blomeyer & Martin, 1991).

There are too many results at variance with the results predicted from theory to justify or to ignore. The six experiments conducted at West Coast University concluded that they have no evidence to believe that the standard Skinnerian program produced significantly better learning than any other form of learning. These results seriously question the necessity of providing practice and reinforcement at each step of the program. However, these experiments indicated that programmed instruction can lead to major advancements in learning theory. These experiments showed that there is much to learn about how to combine and use programming techniques (Blomeyer & Martin, 1991). Gagne and Brown demonstrated that programs could teach by discovery as well as by the usual kind of conditioning. Also, these experimental studies on programmed instruction provided sufficient evidence that programs can help teach a wide variety of subjects and skills. Experiments proved that programmed instruction can be adapted to a great variety of needs and audiences (Gagne, 1964b).

Skinner's contribution to programmed instruction was that he bridged from behavioral science concepts to human learning. Programmed instruction is a tool which would make it easier to break out of traditional learning methods. With the student at the controls, programmed instruction makes it possible for slower students to learn while fewer bright students are bored. It is not yet clear as to how far programmed instruction can stretch the limits within which a given subject is teachable, or speed up the learning process beyond normal average progress. Research already raises certain doubts as to why people learn from Skinnerian programs. By concentrating on the newness of Skinner's teaching machine and other Skinnerian programs, attention was distracted from the importance of the development (Schramm, 1964).

Programmed instruction has affected learning at all levels. Jensen in 1949 used programmed instruction successfully on superior students (Blomeyer & Martin, 1991). Smith and Quackenbush in 1960 (Blomeyer & Martin, 1991), and Stolurow in 1961

(Blomeyer & Martin, 1991) have used programmed instruction successfully with slow learners. Programmed instruction was used successfully to train pilots, packaging and billing clerks, electronic technicians and computer operators. It has been used to teach variety of subjects such as mathematics, statistics, foreign languages, English language correctness, spelling, natural science, philosophy, library use, and a number of industrial business and military skills.

Programmed instruction has been used successfully to teach a variety of behaviors such as root learning, paired associate learning, the application of formulas, construction of deductive, logical truths, formation of concepts, thoughtful reading, troubleshooting in electronic hookups, and reading a radar screen. Programmed instruction has been used in several other forms. It has been used in the form of teaching machines, flash cards, and programmed texts. Programmed instruction has been used in Great Britain, US, Japan, West Germany, and other countries.

Programmed instruction has thus established its credibility as a training tool and as a teaching aid, but its ability to take the place of a teacher in a classroom is not known.

Chapter 3

Computer Aided Instruction

Computer Aided Instruction (CAI) is a powerful educational innovation. The early experiments on computer aided instruction were limited to fairly simple uses such as drill and practice, and tutorials. Complex methodologies of learning theory and instructional strategies were not applied in the early CAI models. The field experimentation of CAI models revealed that programmed instruction and drill were not universally practiced instruction methods, however these methods have limited applicability. The use of a rigidly controlled CAI dialog program in classroom instruction is not reasonable. The rigidity of these programs hinder the creative component of the instructional process (Blomeyer, 1985).

The Huntington project of John Kemeny and his associates at Dartmouth (1958-1959 BASIC) (Baker, 1987) and the Patrick Suppes and Richard Atkinson's project in 1963 (Baker, 1987) at Stanford are among the major contributors of late 1950s'. Project RHEIO (1968-1969), Rural Highlands[1] Educational Improvement Organization, was a drill and practice program designed to complement and reinforce the concepts previously taught. This project was successfully implemented in rural highlands. RHEIO was a computer assisted mathematics instruction project involving mainframe computers and teletypes (Blomeyer, 1985).

PLATO (1970's), Programmed Logic for Automatic Teaching Operations, project of Donald Bitzer and his colleagues at the university of Illinois, Alfred Bork's (1969)

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[1] The authors did not identify the "Rural Highlands" for confidentiality reasons, but it is believed to be in Kentucky.

developmental work of CAI material for the instruction of physics, and TICCIT (1971), Time shared Interactive Computer Controlled Information Television System, a project under Victor Anderson, all came short of fulfillment. When teachers properly integrated CAI programs into the class curriculum and administered the program, the results were very impressive. However when they failed to integrate the programs into the class curriculum, the results were completely lacking. Although Educational Testing Service's (ETS) evaluations of PLATO and TICCIT were very positive, the test results were far from gratifying. The effectiveness of CAI as a teacher was still an unanswered question (Blomeyer, 1985).

By the late seventies several projects were undertaken to bring the true potential of CAI into the educational institutions. Some of efforts of the seventies were CONDUIT (1976), a Consortium of the universities of Oregon, North Carolina, Dartmouth, Iowa and Texas, headed by James Johnson and Hal Peter, MECC (1970), the Minnesota Educational Computing Consortium, led by Kenneth Brumbaugh, and NDPCAL (1972), the National Development Program in Computer Assisted Learning, was directed by Richard Hopper in the UK (Baker, 1987).

Findings from a number of experimental and quasi experimental studies on computer assisted instruction (Baker, 1987; Kulik & Kulik, 1986; Sampson, Niemiec, Weinstein, & Walberg, 1986; Kulik, Kulik & Cohen, 1980) and a variety of naturalistic studies support that CAI has a great potential as a tool to improve teaching and learning. The studies on the effectiveness of technological intervention has also been questioned because existing research seldom demonstrates statistically significant findings (Blomeyer, 1989).

Existing quantitative research in computer assisted learning does little to illustrate links to classroom learning (Blomeyer & Martin, 1991). Research findings provide unclear methodological or policy guidance on how to optimize the instructional effectiveness of computers in schools. Experiments present evidence of computer assisted instruction's effectiveness in mathematics instruction, but its impact on the instructional methodology is limited because of its limits on generalizability beyond a specific experimental treatment. The study of Robert L. Blomeyer Jr., (1985) at the University of Illinois, established a measure of applicability of computer assisted learning to foreign language teaching (Blomeyer, 1985).

The MEP, Micro-Electronics Program, was financed by the education departments of England, Northern Ireland, and Wales in March 1984. The aim of MEP was to provide a suitable basis for the development of courses, teaching skills, and learning materials. Prior to MEP, the National Development Program in Computer Assisted Learning, NDPCAL, was funded and established. The personnel involved in the NDPCAL project had done the necessary groundwork to facilitate micro-technology and computer assisted learning in the educational institutions. MEP was able to identify computer assisted learning initiatives already in existence and was able to support and strengthen them. MEP was able to encourage new CAI initiatives at national, regional, and local levels. The scope of MEP extended beyond computer assisted learning to embrace the applications of micro-electronics and to cover the needs of children in an information society.

Another such project was SMDP, Scottish Micro-electronics Development Program of Scotland of 1979. The objective of this program was to promote micro-electronics and computers among students and teachers, to use computers in a curriculum context for learning and for assessment purposes, to produce curriculum material for teaching purposes, to exploit micro-electronics to assist students with special needs, and to use micro-computers in school management. Similar projects were initiated in the USSR and other European countries. The USSR developed automated teaching systems (AOS) which were seen as powerful means of solving the problem of optimizing the process of teaching. AOSs were computer based systems. They automated many didactic functions, ensuring complete or partial replacement of the teacher. They were creating adequate conditions for the cognitive activity of students. In principle, these AOSs could be used to teach a number of subjects at all stages of learning. These systems were used in several schools and colleges (Cherniavskyi, 1980).

SADKO, a teaching system for automated dialog and group learning, was used effectively in Moscow Technological Institute of Food Industry. The main teaching material was contained in a printed textbook and was displayed on a screen. The student responses to the questions were entered on the terminal and could be edited. The system then evaluated these answers and displayed the appropriate feedback. Similar systems were used at the Riga Polytechnical Institute (Nitsetskiy, 1979) and the Belorussian State University (Cherniavskyi, 1980).

In the 1980's many tutoring systems were implemented in various instructional domains. Tutoring systems performed well when the instruction domain was analytical such as mathematics or language grammar. Furthermore, these performances were encouraging when the domain was very narrow, such as solving binomial equations or explaining a grammatical structure. In other words, the narrower the instructional domain, the better the tutoring systems were. In broader domains, the tutoring systems tended to became irregular. In general, tutoring systems performed better in the domains that were increasingly objective. However, where creativity, individual psychology, and individualized instruction of students were in question, CAI lacked the necessary tools. Thus, the individualistic form of instruction to suit the tutorial context eluded the early CAI models (Blomeyer, 1985).

The results from PLATO, TICCIT and other computer assisted learning projects suggest that CAI had been found wanting in several key respects. Though the performance is not yet well established, CAI can be an effective tool under proper conditions. Drill and practice, tutorials, substitute tutor, and simulation were the identified areas in which computers can function as a teaching aid for classroom instruction (Blomeyer, 1985).

Project RHEIO:

Project RHEIO, Rural Highlands Educational Improvement Organization (1968-1969), was a computer assisted mathematics instruction project involving mainframe computers and teletypes. This project was a drill and practice program designed to complement and reinforce the concepts previously learned in the classroom environment and was successfully implemented in rural highlands, where.

RHEIO employed a three stage evaluation model (Russell, 1969). The first stage was the experimental design which dealt with the summative evaluation of learning outcomes. This evaluation process involved careful measurement of academic achievement gains using standardized instruments, pre and post tests, and controls groups. The second stage of the evaluation focused on effective attitudinal domain using various survey research techniques with properly designed questionnaires, interviews of pupils, parents, and teachers. The third stage was the participant observation and field work. A brief tabulation of this model is given in table 1 (Stake, 1967 and Scriven, 1967).

Project RHEIO focused on the teacher's utilization of CAI as a supplementary mathematics program and the pupil's behavior at the teletype. A major finding with regard to teacher utilization was the wide variability that was observed in the teacher's utilization of the system resources. Such variance included the degree of integration with classroom activities, the use of printouts, recording results, routines for dismissing children to the terminals, priorities signed to the program, understanding of the nature of CAI, and frequency of usage. Much of this variance could be attributed to the frequency of down time and a poorly articulated communications network.

Technological and Theoretical Basis	Inquiry Process	Analysis of the Evaluation Instrument	Model Roles	Focus
Psychological	Experimental Design, randomly assigned experimental and control groups within class, pre and post tests of achievements.	Standardized achievement tests.	Summative	Students
Sociological	Panel surveys, Construction of favourability indexes.	Structured student attitude questionnaires, parent interview.	Summative	Students and mediators
Anthropological	Participant observation field work	Observers': field notes, informal interviews, documents	Summative and formative	Students, mediators, materials goals

Table 1: Cemrel evaluation model used in RHEIO project

Observation of the pupil's behavior at the terminals lead to interesting findings. Often, children were seen engaged in a dialog with the terminals. This pupil's behavior at the terminals emphasized the social significance of CAI. This behavior was observed more often in the group activities rather than in the individual activities. It was also observed that group and individual activities at the teletypes evolved into varying forms of competitions. These issues became inter-woven with the problems of teacher assistance and supervision. At this juncture, the RHEIO project members began to see CAI as a complex mixture of physical, social, emotional, and cognitive behaviors shaped both by administrative routines and norms of the particular school and classroom.

The RHEIO project concluded that CAI was not just an educational tool, but a complex social and technical system. Without technical expertise and support, the success of CAI could be jeopardized by the complexity of technology and the social reception to technology. Some of the serious problems encountered in this project were high down time, poor performance of teletypes and data sets, lack of good communication facilities, and inconsistency in hardware performance. Traditional text book bound teaching of mathematics involves a lot of drill and practice. Consequently, when teachers engaged in classroom drill and practice exercises, CAI's major potential to save classroom time for concept development and individualized instruction was greatly minimized due to these problems.

RHEIO also found that CAI was utilized in diverse ways. On a gross level, significant differences among teachers were observed in the integration of CAI with the regular classroom programs. Such differences ranged from no attempt at the integration of classroom instruction and CAI to constructing the entire year's mathematics program around CAI programs. The teacher's education, knowledge and exposure to the technology influenced the effectiveness of CAI in the classroom. The degree of integration with the classroom activity was a significant factor in the effectiveness of CAI as a teaching aid.

The following issues were observed to be important in the successful implementation of project RHEIO:

1. Students were observed to be enthusiastic about working with CAI systems. Initially, the enthusiasm of the children was observed to be overwhelming. It was also observed that the student's attention and concentration was intense during the initial sessions. This experience of an initial outburst of attention, concentration and enthusiasm might not be universal. After the decline of an initial attraction, the

ability to maintain attention, concentration and enthusiasm of the children remained questionable.

2. The degree of integration of CAI with classroom activity was a significant factor in the effectiveness of CAI as a teaching aid.

3. The teacher's education, knowledge and exposure to the technology influenced the effectiveness of CAI in the classroom.

4. A careful examination of the interaction between personality variables, study skills, and learning devices was essential. Key variables were:

   A. Emotionality, anxiety and exhaustion: Emotional behavior was more noticeable among the students. Extreme nervousness was observed at times. The students were self-conscious about others around them. Some of the students who had difficulty with drills found that CAI was exhausting.

   B. Verbal interaction between the child and computer: One of the most interesting behaviors observed was the verbal interaction between the student and the teletype. In that respect, this simple drill and practice program seemed to have become a higher level tutorial program. Sometimes the verbalizing took the form of self-criticism.

   C. Effects of CAI as a group activity: Working together was necessary especially when the student could not read. Occasionally, the aide became heavily involved with the work. This aide's involvement resulted in biased evaluation because the errors were corrected before they were entered into the computer.

   D. Competition: An unanticipated social activity of CAI was the competition. The competition appeared to vary across schools, classrooms, subgroups and individuals. The reason for this variance was not known, but the variance was observable. The competition took several forms:

      - Completing the greatest number of drills on a given day.

- Completing a drill in the shortest amount of time.
- Achieving the highest scores on a given drill.
- A combination of time and score.

E. Self-competition: Another social activity of CAI was self-competition. The emotional reactions of delight and despair were usually accompanied by the accomplishments and disappointments to better their personal bests.

F. Visibility of accomplishments: Visibility and recognition of accomplishment, whether by word of mouth or public display, were unexpectedly high.

Project PLATO:

The PLATO project (mid 1970's), Programmed Logic for Automatic Teaching Operations, of Donald Bitzer and his colleagues at the University of Illinois, was one of the major CAI projects initiated to develop CAI tools for classroom instruction of mathematics.

PLATO was a computer based teaching system individualizing student instruction. It's lessons were designed to allow students to work at their own pace. Lesson performance was recorded and evaluated by the computer located at the Computer based Education Research Laboratory (CERL). The terminals were equipped with a typewriter keyboard and a touch panel Each child responded to directives and questions on the screen by touching it or by typing a message onto the screen. PLATO responded to the children's directives and prescribed work according to the child's previous performance. Children learned mathematics as they interacted with the terminal to work the lessons presented on the screen. Animated graphics helped keep attention on the screen.

In 1974, as an ETS experimental study, PLATO was implemented in twelve classrooms in the Champaign Urbana area. The single most unique feature of PLATO was the plasma display panel, allowing students to respond to directives and questions by touching the screen. The teacher's role was a major determining factor of the climate in the classroom. Children were given more and more freedom as they accepted responsibility.

This experimental study at the Champaign Urbana area was designed to provide an in-depth understanding of the children and the teacher. It was decided to use the naturalistic responsive approach (Guba and Lincoln, 1981). The design of this experimental study came mainly from the educational research approach of Robert E. Stake (1975,1979). The methodology was also influenced by Sylvia M. Scravner (1967). The teacher's classroom observation logs, interviews, and random observations of the students at the terminals were used to collect information. Formal interviews were conducted twice a year with selected students and teachers. An attempt was made to examine both the activities around the terminal and the activities in other parts of the room to see if there were differences. Also, an effort was made to determine if the students were governed by the terminal or if they controlled the terminal.

Ms. Shelia Hamilton, a fourth grade teacher, structured and controlled the environment to allow the children freedom to work independently and to be creative. This freedom was dependent upon the children's expectancy of responsibility in making choices. The children were given more freedom as they accepted responsibility. However, they were not responsible for determining the content of their lessons. The children could select when to work on required lessons and their privileges were determined by their ability to finish the work.

Some teachers organized the use of PLATO to give every student a turn. Other teachers had difficulty (or did not bother) in organizing the classroom for implementation of PLATO. Some considered PLATO an add on to the classroom activity and others set aside a specific time each day for a child to work at the terminal. Ms. Hamilton discovered that PLATO had the potential for motivation and control of behavior. PLATO served in part as a reward for good behavior in the classroom. PLATO seemed to provide special private space for some children. Some children had the opportunity of learning in a non-threatening atmosphere and at the same time be rewarded by instant feedback. By using PLATO, Ms. Hamilton was able to reach the children who seemed to find most of their school day an unrewarding experience. While Ms. Hamilton integrated PLATO mathematics into her curriculum, many of the other teachers in the ETS study used PLATO as supplementary mathematics and did not try to coordinate it with the school mathematics curriculum. Ms. Hamilton gave some extra PLATO time to the children who needed additional help. This helped motivate some of these children. After a few weeks of whole number lessons, Ms. Hamilton found definite improvement in the multiplication skills of the children. She found that the children had taken pride in their improvement and were working against their own achievements. Some of the areas of development in children are: scan reading, phase concentration, attention span, problem solving skills, hand-eye coordination, finger dexterity and learning.

The most important achievement of PLATO was to create enthusiasm for learning mathematics. PLATO was able to teach mathematics to children. PLATO was successful in teaching mathematics to children because Ms. Hamilton was able to integrate PLATO with her own math curriculum. PLATO was used as a tool and not as a stand alone instruction system. PLATO was able to increase the children's ability to understand the number system, but it also gave the child a special lesson in the complexity of technology. Ms. Hamilton planned a curriculum to build on strength and remedy the weaknesses. The children worked at their individual level and continued to progress. PLATO brought many opportunities to increase the repertoire of cognitive and affective experiments of the children. The spirit of competition was strong and struggles to win were observed. However, competition appeared benign. The cooperative and helpful spirit in the classroom among children, however, overshadowed the effects of competition. Children helped each other with lessons.

In many lessons, making mistakes was a rule rather than an exception. Children that were embarrassed by mistakes when they started to use PLATO, later became accustomed to mistakes as part of the process of solving the problem. Easily and Zwoyer (1975) have shown how students cope in school using trusted schemes tempered by experience. Some schemes are inappropriate. Students need the opportunity to try out their schemes. Students using PLATO had opportunities to understand the relationship between their scheme and PLATO's. The errors got special attention. Though PLATO did not understand the errors, Ms. Hamilton did. Case (1975) and others argued that children gained a better understanding when the learner's errors and justifications as well as correct answers received attention. PLATO reacted to many responses, but could not cope with problems like Ms. Hamilton did.

The elementary mathematics lessons on PLATO were more humanistic. They retained individualistic expression and gained attention to the implications of the learner. PLATO created challenge, competition, and a sense of accomplishment. It provided a place for children's innate creative and compassionate senses to mix with cognitive, when teachers like Ms. Hamilton were able to take advantage of the system.

PLATO achieved measurable success as a CAI tool teaching mathematics under the effective guidance of an understanding teacher. The teacher played a significant role in integrating PLATO and it's math curriculum into the classroom. With organized lessons and activities, a class teacher integrated PLATO as an effective drill and practice tool. An understanding class teacher, who could effectively integrate PLATO and the math curriculum, was the key to the success of PLATO's innovation. The major limitations in PLATO's success were very high cost, complexity of curriculum design and hardware problems. But PLATO established that under the able guidance of an understanding teacher CAI could be a very effective individualized instructor.

<u>Computer Aided Learning in Foreign Language Teaching.</u>

Robert L. Blomeyer's study of micro-computer use in foreign language teaching was conducted in 1983-84 as field work for his doctoral dissertation. Although Blomeyer's case study had methodological and theoretical linkages with the studies of Smith and Pohland (1974) and Stake (1977), it did not detail the macrostructure of local culture (Smith & Pohland, 1974), or microstructure (Stake) of the classroom. Blomeyer stated that the dominant form of interaction in foreign language teaching was drill and practice method. There was little evidence that signaled the beginning of a revolutionary change in this dominant conception. In contrast, McLaughlin's study illustrated the transforming effects of generic microcomputer based tools as an instrumental method for literacy acquisition and the social empowerment of Navajo students. The difference between the apparent social outcomes of traditional CAI, the use of computers as a supplement to direct instruction, and the alternative use of microcomputers as emancipatory tools pointed out a potential asset for new curricula to advance the empowerment of minority students.

The objective of Blomeyer's study was to provide a practical and relevant basis for making decisions regarding the utilization of this new instructional technology. This study was based on studies of diffusion of innovation that was common to cultural anthropology, rural sociology, and educational research. The compatibility of an innovation with existing socio-cultural values, beliefs, previously introduced ideas, and need for additional information, has a great influence on long range outcomes for continuing adaptation or rejection of an innovation (Rogers & Shoemaker, 1971).

The quasi-ethnographic model was used to guide Blomeyer's case study field work, data analysis, and contrasting of school sites to establish a basis for a comparative analysis of naturalistic data (Lecompe & Goetz, 1984). The data categories used to describe computer assisted learning in foreign language teaching are: (a) base line data, or information about the human and technological context of the students, instructional staff, and community setting; (b) process data, or information derived from observations of computer assisted learning activities in these settings; (c) value data, or information of the values of the various participants and the values implied by the use of computer assisted learning .

Blomeyer's study was significantly influenced by multiple site case studies of computer assisted learning by Smith and Pohland (1974). Smith and Pohland believed that anthropological methods grounded in cultural theory would produce research findings useful for educational improvement. The methods employed in the field work for this case study were chosen to maximize applicability of findings for the improvement of instructional practice and to minimize potentially disruptive effect on classroom based naturalistic research. Naturalistic inquiry techniques minimized intervention into the routine functioning of the classroom and school settings and are preferred by many researchers for school based educational research (Guba, 1978).

Blomeyer's study used a standard approach to site access and field methods. Site access was negotiated between the researcher and the school district with the help of a foreign language specialist. Strategies included participant and non-participant observations and interviews. Woodville West High School and Hilldale Community High School were selected for the case study. Both these suburban sites were alike in terms of size and their overall educational programs. However they were very different in the way they approached instructional computing at school level. The language teachers who cooperated with this study were leaders in the use of micro-computers in foreign language curriculum.

Both Woodville and Hilldale were small communities. Both communities offered a four year comprehensive high school education program with a weighted grading system. Basic background information for both of the community high schools is tabulated in table 2.

	Woodville west high school	**Hilldale community high school**
Population	33,000	80,000
Median Income	$32,000	$30,700
High school Program	Basic Regular Accelerated Honors (Advanced placement)	Fundamental General Regular Superior Honors (Advanced placement)
Students (9-12 grades)	2,200, about 77% graduates went to college. 10% of graduates took calculus and English A.P exams. Out of 291 A.P scores 192 were 3 or better (Scale 0-5)	3,600, about 72% graduates went to college. 10% of graduates took calculus and English A.P exams. Out of 202 A.P scores 165 were 3 or better (Scale 0-5)
Courses	English, calculus, European history, US history, biology, chemistry, physics, German, French, and Spanish.	English, literature courses, calculus, algebra, computer science, European history, US history, biology, chemistry, physics, music theory 1 and 2, German, French, Spanish, Latin, and Russian.
Staff	165	232
Pupil/Teacher ratio	13 to 1	11.5 to 1

Table 2: Baseline Data Summary - Blomeyer's Study.

In these two schools, the treatment of computer assisted learning as a curriculum component was very different. At Woodville the default definition of instructional computing was math, science, or computer technology. Usage patterns of micro-computers were established on a first come first serve basis. As a result, teachers who were not early adapters had difficulties accessing the computers. At Hilldale, proper curriculum planning resulted in proper utilization of micro-computers by all students and teachers. The policy frameworks in both schools had distinct implications for instructional practice. Though the instructional methods and foreign language teaching were common, the interactions involving the teachers, the students, and the computer assisted learning material were different.

The foreign language teachers who cooperated with the field study used computer based foreign language instruction as a supplementary instructional strategy in beginning and advanced classes in French, German, and Spanish. In all these cases, the interactive computer assisted lessons used were designed and implemented or modified by the cooperating teachers or other instructional personnel in the respective schools. Although both schools had large foreign language departments, only the four teachers whose classes were observed during the study made use of available computer assisted learning material.

The cooperating teachers were generally knowledgeable and were contributing to the design and implementation of computer assisted learning. From the observations, it was evident that field testing a prototype lesson was a very labor intensive undertaking. Once revised and completed, the grammar drill would probably be a significant resource for the class. However, the time required of the teacher to design prototype development, field testing and revision was significant. The teachers that were observed, used a wide variety of learning activities and instructional strategies in their classroom teaching. These activities included both oral and written practice on vocabulary and grammar as well as presentation of cultural aspects of the lessons.

The integration of computer based instruction into the foreign language syllabus design was accomplished by incorporating subject matter from traditional class materials. The courseware designed by class teachers was closely tailored to the particular content of the individual classrooms. The individual lessons used the drill and practice format covering the same vocabulary and grammar as the regular lesson material.

Preliminary analysis of field notes indicated that the use of computer assisted learning in the foreign language instruction appeared to be resulting in some structural and procedural changes in teaching practice. The gradual accumulation of information pointed to a number of potentially relevant issues that required further study. The issues were categorized as follows.

1. Implementation strategy: (similarities and differences)

    A. School's policies that defined the student's and staff's computer literacy.

    B. School's policies influenced use of computer assisted learning in the classrooms.

    C. Student access to work stations.

    D. Site implementation and hardware differences.

    E. Lesson design similarities.

    F. Similarity of sources of lesson materials.

    G. Similarities attributable to teachers.

    H. Similarities attributable to teacher computer literacy.

2. The cost of integrating computer assisted learning as a component in foreign language curriculum.

The integration strategies that the teachers in both schools were using to make instructional computing a functional part of their foreign language teaching programs required the ability to match the computer based resources and existing instructional material. Making these judgments required that the teachers be familiar with software and computers. The teachers actively participated in the lesson design and implementation. The teachers participating in the study believed that the in-service training they had received was adequate to enable their own use of computer assisted learning. They also expressed opinions that the majority of foreign language teachers in their schools were not ready to begin using computer assisted learning because of the limited availability of appropriate instructional software.

3. Instructional material.

The teachers who contributed to developing the teaching material paid a price in terms of their time and energy. The lesson materials used in the classrooms had a high degree of compatibility with regular instructional material. However, the cost of this comparability between the instructional computing and classroom teaching was high.

Although successful integration of computer based materials into a syllabus was the result of developing and using teacher-produced interactive teaching materials, the design and implementation of computer assisted learning was demanding and time consuming. Based on this, it seemed logical to use commercially used language teaching materials. The task of locating, prescreening, and selecting suitable instructional software was also time consuming and difficult. Teachers found that the commercial programs used were of questionable relevance and needed corrections which were difficult and problematic.

In summary, integration of computer assisted learning in foreign language teaching appeared to be labor intensive whether the interactive material was purchased from vendors or locally developed.

4. Computer literacy issues.

Observations suggest that student computer literacy was a major factor effecting the use of computers in foreign language curriculum. Instructional and admission prerequisites would insure necessary training and computer skills in the students that would help instructional computing. Students lacking the introduction to computer literacy appeared less able to use computer assisted learning efficiently.

5. The potential impact of computer assisted learning on teaching practices as apparent in language teaching.

Although computer based instruction was being used as a part of a foreign language curriculum in both the schools, the overall impact of this micro-computer use on teaching practices appeared to be minimal. Some activities that might have been conducted by teachers during the regular class time were vocabulary reviews, verb conjugation, and adjective or pronoun agreement, which seemed to be the subject matter that was most suitable for the computerized drills used by the students.

The instructional use of computers and the regular foreign language class activities that were observed in the two schools seemed to support the notion that the use of computers in the classroom might not have any strong effects on classroom practices. It seemed more likely that the core practices would dominate the conception of computer based instruction. Though the teachers integrated computer assisted learning as a limited portion of the curriculum design, the majority of their class time was spent on traditional classroom learning.

Computers were viewed as tools with the potential to revolutionize the existing educational system. A far reaching speculation had suggested that the increasing availability of computers and other powerful problem solving tools would provide instructional experiences. This would shift the dominant concept of formal learning towards individualized learning. (Pappert, 1980a). Some shift in the dominant core practices towards individualization was noted during the observations. This shift resulted in a change of a teacher's role from direct instruction to a resource provider who monitors self-pacing and individualized instruction. Once the programs were loaded and the majority of the class was working on the lessons, the teachers were free to assist individual students. However, within the framework of this field study, there was little evidence that signaled the beginning of a revolutionary change in the dominant conception of learning.

Another significant characteristic of traditional instruction was the teacher's reliance on the text books as a source of instructional material. In an effort to integrate computer assisted learning into their curriculum, the teachers used vocabulary and grammar material common to the other traditional instructional materials. In other words, the observations suggested that the majority of foreign language teachers would not use computer assisted learning until integrated materials were produced by the text book publishers.

6. The potential impact of computer assisted learning on efficiency, equity, and quality of education.

   Observation and interview data suggested that a policy requiring universal student computer literacy might have a positive influence on the equity of instructional computing. It appeared that the use of computers as a curriculum-wide instructional resource would provide greater equity than restricted use in one area of the curriculum.

Research conducted by Sheingold, Kane, and Endreweit (1983), and funded by National Institute of Education concluded that their findings lacked specific information on how computers affect educational practice. Their results suggested that the effects of micro-computers on education would depend, to a large extent, on the social and educational contexts within which they're imbedded. Experimental and quasi-experimental studies comparing computer assisted learning to other instructional methods often showed no significant difference between the performance of experimental and controlled groups. (Solomon and Gardner, 1986).

Experimental studies by Solomon and Gardner (1986), and Baker (1987), resulted in weak findings, which might be due to the use of inflexible or unreliable quantitative measures. These findings might also be problematic for analysis because they offered no contextual information. But research conducted in this direction by Sheingold, Kane, and Reweit (1983), Solomon and Gardener (1986), and Baker (1987) suggested that the effects of micro-computers on foreign language instruction were context dependent. Within that context, due consideration should be given to the sub-domains of influence that help understand the instructional procedures by which computers and instructional technologies were integrated as a component of the curriculum.

The specific sub-domains that influence CAI's effectiveness include the following:

1. Hardware and site implementation.
2. Availability of access to work stations and other resources.
3. Design characteristics of the software with particular attention to interactive characteristics of computer assisted learning , and ease of use.
4. Curricular and disciplinary sources of lesson materials.
5. Pedagogical characteristics of content domain or the training of teachers as content specialists.
6. Computer literacy of students and teachers.

Model Language and Literacy Project at Navajo School

In the Navajo project interactive micro-computer technology became an important tool that supported literacy instruction by allowing students to manipulate both the native and second language in a highly interactive manner. This project was conceived in 1983 at K12 Navajo bilingual school, and funded by federal grants.

The Navajo literacy project was dedicated to the development of students' thinking, reading, writing, and speaking abilities in Navajo and English. Computers, with Navajo-smart word processors, were utilized to teach different word processing and dBase programs to the students. The products constituted elements of a community bilingual newspaper as well as programming material for a low power community television station. All of the products measured against a model of thinking that ensures cognitively complex activity.

The educational system empowered the child and hence the child was able to realize success in school. Empowerment was facilitated by including the child's culture and linguistic characteristics in the curriculum and instruction. Otherwise the educational system would become an impediment to the child by not including those characteristics (Cummins, 1986). Cummins identified the educator's role as additive or subtractive relative to the student's cultural and/or linguistic characteristics. The educational institution included community involvement either by collaborating or by excluding them from the education of their children. The teachers themselves could either teach in a reciprocal or interactive mode whereby students were active participants in their education, or they could be passive as teachers that merely lecture. Finally, the assessment of the child was oriented in either legitimizing the perception that the child was incapable of performing and being successful or the education system became an advocate of the child by using assessment as a source of diagnosis and direction to meet the needs of the child.

A curriculum was organized along Navajo research, English research, computers, and performance. The second dimension of curriculum consisted of cognitive goals specified according to grade level. And the final goal was to write editorial articles for community newspaper. Using computers, students learned to use Navajo-smart word processing and dBase programs. In performance, students analyzed the topic of critical importance to the individual, the school, the community, or the tribe, by preparing video tape products to be aired over the community's television station. The program was for everybody and the students rotated one activity to the next. In this fashion, by the end of the year, each group would have completed the four class activities.

Based on the responses of the students who wrote about the project in the community newspaper, the project was a success. The statistics gathered by pre and post tests measurements were impressive. In the program's first year student's success rate on CRTs was 91%. In the following two years the rate was 95%. Student's standardized test scores also indicated significant growth. Students recorded twice the amount of growth in pre and post tests of reading comprehension in English than nearby BIA schools.

Language and literacy situations differ from one community to another. In order for CAI programs to be successful the content of effective language must adapt to the changes brought about by CAI. In this project interactive computer technology became a viable tool which supported instruction by allowing the student to manipulate both the native language and English in a highly interactive manner.

Though the project was successful there was no evidence to attribute CTBS test gains solely to the project. Prior to the project, the school's test scores on standardized measurements compared favorably with those of nearby comparable schools. A more accurate observation would be the gains in speaking and writing as observed in the project's pre and post test data.

TICCIT System:

TICCIT, Time shared Interactive Computer Controlled Information Television, is a time shared CAI system, providing individualized instruction simultaneously over color video terminals with computer generated and video display capabilities, as well as, audio messages. This system included content control and self pacing. TICCIT differed from conventional CAI systems in that the basic instructional software on the system was designed to facilitate learner control on many potentially important dimensions (O'Neal, 1977). The primary use of the TICCIT system had been to deliver full courses with emphasis on the idea of display or strategy control (Merrill, Schneider and Fletcher, 1980). In spite of contradictory research findings, sufficient evidence exists to suggest that, given the choice, students select patterns of learning (Elliot, 1976; Lahey and Crawford, 1976; Spiller et al, 1978) and that some patterns may be more successful than the others (Elliot, 1976; Spiller et al, 1978).

It is also observed that achievement and efficiency were not generally effected by allowing students to control the sequence or amount of their instructional components. Of all the student characteristics investigated, only aptitude and capability of self-assessment seemed to interact with learner control, but the research findings were contradictory. A critical assessment of the research literature indicated that most of the studies were based on short-term experiments involving a small number of subjects, largely on a voluntary basis. In addition, the material to be learned was limited to modules or segments to be completed in a matter of a few hours. It is questionable whether the motivation to maximize one's learning efficiency and effectiveness by using learner controlled options was likely to be presented under the above mentioned conditions.

The TICCIT project was implemented in 1971, at Alexandria Campus and Phoenix College, Arizona. An algebra-I course and an English grammar course were taught to 148 students on TICCIT. This study attempted to overcome the limitations of previous research by involving a large group of students in a real educational setting, who are registered for one of two courses taught using the TICCIT CAI system. The students were expected to attain mastery of their course objectives within one academic term and receive a grade accordingly. If learner controlled options had an effect on learning efficiency or effectiveness, it would be more evident under these realistic circumstances. This study employed two options.

1. Students could choose which content to study first by selecting units, lessons, and segments in any order.
2. Within each instructional segment they could choose the type of display to see next. This display may be expository (the rules), or worked examples of the concept to be learned, or practice questions which require a response from the students. Each of these displays were available in four levels of difficulty: hard or concise, easy, help with worked examples, and medium or average level.

Since students lacked sufficient knowledge of the content, they selected the lessons in the order in which they were listed. An individual student's keypress records were analyzed to identify patterns employed by each student. Keypress records analysis revealed that students had developed forty five different patterns of display while working through the course. Three of these patterns accounted for 65% of the segments generated. They were:

A. Rules, Examples, and Practice (R.E.P. pattern).

B. Rule and Practice (R.P. pattern).

C. Practice (P. pattern).

The keypress record patterns and the distribution of the segments are tabulated below.

Pattern Label	Pattern	Number of Segments
A	R: E: P	320
B	R : E : P + misc keys	91
C	R : E : R + misc keys	75
D	R : P	300
E	R / R : P + misc keys	93
F	E / E : P + misc keys	41
G	E : P / P + misc keys	77
H	P only	155
I	P : R + misc keys	44

Table 3. Distribution of key press patterns employed by all students.

Analysis of this information indicated that the RP pattern as a successful approach for math course. Whereas failure to use P pattern was detrimental to the completion of the math course on TICCIT. The P practice only was contradictory for both math and English courses. The Practice option was beneficial to English, but was detrimental to the timely completion of the math course. This study indicated that study patterns differ significantly according to the subject matter. The findings of the study did not support any specific pattern as paths to success in TICCIT delivered courses. Most of the students developed study patterns which used only two of the three primary forms presented. Pattern choice seemed to be influenced by the topic to be studied.

This study showed the learning patterns and their relationship with the subject matter. However, it did not point out the advantages or disadvantages of using a computer system in the instruction of the subject matter.

<u>Interactive Instructional Authoring System Version 1 Release 2.0</u>

The Interactive Instructional Authoring System (IIAS), an authoring system developed by IBM, provided the capability to create and maintain computer based training courses. These courses would run under the Interactive Instructional Presentation System. a companion product which was a pre-requisite.

The authoring system could be divided into three sections; course structuring facility, simulation exercise facility, and course writer language. The course structuring facility provided simplified course development and course organization. Using worksheets the course structuring facility allows for entering, analyzing, and structuring text information for tutoring, questions, and screen formats. The simulation section provides training exercised by topic. The course writer language assists the author in the implementation of instructional strategy. This evaluation was based on the information available. This system can be used to develop courses based on Skinner's reinforcement theory and Crowder's recognition theory. Like most of the authoring systems that were previewed, this system also has an authoring language, screen development tools, and other tools to help design the lessons.

Chapter 4

Intelligent Computer Aided Instruction

A. Intelligent Computer Aided Instruction.

Intelligent Computer Aided Instruction, ICAI, attempts to approach the learning situation from a less controlled, less technology driven, and more student driven perspective (Sleman and Brown, 1981). These programs allow learning via discovery and by the development of problem solving skills.

Artificial intelligence is defined as the science of making machines do things that would require intelligence if done by men. This implies that machines do not have intelligence (ability to learn, reason, or understand), but they can be made to simulate intelligence. The objective is not to create a machine that can think, but to model thinking (Borden, 1977).

SCHOLAR was the first system that departed from conventional frame oriented CAI. It was developed by Carbonell in 1970 using artificial intelligence techniques. SCHOLAR could be regarded as a generative information structured program. It was developed to teach facts about geography. It was designed around a simple data base of geographical facts, where the interrelationships between the facts were specified. Also, these databases could be used to check unanticipated answers to questions. This type of program can generate instructional material and can be modified to cover a new subject area very easily. However, as the knowledge in the database increases, search problems and the number of false paths increases. SCHOLAR could interpret restricted English input and generate responses. It was comprehensive and utilized restricted natural language for both input and output.

However, SCHOLAR did not attempt to evaluate student's responses or help the students to overcome misunderstanding or misconceptions by analyzing the responses. Thus it failed to rectify one of the drawbacks of frame oriented CAI. Proponents of ICAI argue that conventional CAI represents a theoretical assumption that knowledge can be divided into lessons which are taught on a frame by frame basis. However this frame oriented CAI results in poor utilization of computer resources (Barr, Beard, and Atkinson, 1975). SCHOLAR was intelligent in its capability of dealing with student's misunderstandings. But SCHOLAR had no ability (built-in) to deal with a student's basic learning difficulties or to the ability to adapt to a student's attitudes.

Most ICAI systems attempted to profile successful tutors. Since the presentation of information was more learner driven, focus of the systems was to guide the students through the learning process. SOPHIA, a system intended to help electronic engineering students to locate the faults in malfunctioning electrical circuits, was an impressive example.

SOPHIA was designed as a simulation program for teaching electronic trouble-shooting. This program encouraged students to explore ideas and hypothesis and provided them with immediate feedback about the validity of the ideas. SOPHIA did not attain the depth and breadth of knowledge of a human expert, but in a carefully chosen restricted domain of expertise, SOPHIA could answer virtually any question. The price of accomplishing this goal was a highly complex program (Brown & Burton, 1974; Brown, Burton, & Bell, 1975).

The student could interact with SOPHIA in his learning process. Information exchange of hypothesis helped create a problem solving environment where feedback was actively used in the actual logical deductive strategy the student would use. Basic Instructional Program, BIP, of Stanford University is another example of interactive learning or learn by problem solving. BIP assessed the student's skills and assigned problems to improve them. The Stanford BIP program successfully modeled the students (Barr, Beard, and Atkinson, 1975). SCHOLAR, SOPHIA, and BIP are considered as generative systems.

One of the important characteristics of the intelligent tutoring systems is student modeling. This is also one of the strongest tools of a human teacher. ICAI systems attempt to develop student models to effect a better match between instruction and student. In general, these programs attempt to discover the fault or defect in the student's thinking or understanding and offer appropriate tutorial advice. Tutorial programs like BUGGY and WEST are of this category. BUGGY is a computer based program devised to teach students mathematical reasoning and structure of mathematical skills. WEST is an intelligent game employed to coach students in basic mathematics. The computer coach is the expert, but the overt objective is to win, not to learn. Yet, interestingly students that were coached seemed to enjoy the game while they improved mathematics.

ICAI attempts to instill problem solving expertise. It attempts to model the student and devises particular instructional strategies. Though a computer is good at problem solving, modeling, and devising instructional strategies, ICAI is still in the beginning stages and its development process is full of unanswered questions. It is manageable to design a learning package that imparts information to a student, whether frame by frame, or via visual media, or lecture. It is far more difficult to design an information structure, which is controlled by the user, to model the acquisition skills and to design programs which allow for all possibilities of reason and misunderstanding.

In order to assess the merits of ICAI programs, it is necessary to compare their abilities with the desirable properties of a human tutor (Gable & Page, 1980). They are:

1. The tutor causes the problem solving heuristics of the student to converge to those of the tutor.
2. The tutor will learn and adapt student solution methods if they are superior.
3. The tutor chooses appropriate examples and problems for the student.
4. When the student needs help, the tutor can recommend solution scheme choices and demonstrate how to apply the techniques.
5. The tutor can work arbitrary examples chosen by student.
6. The tutor is able to adjust to different student backgrounds.
7. The tutor is able to measure the student's progress.
8. The tutor is able to review previously learned material with the student as the need arises.
9. The tutor will give immediate feedback on errors.
10. When the student has solved a problem, the tutor may point out more direct solutions.

More recent versions are capable of building a current state of knowledge model of individual students who are using the system. Thus, students were presented with problems which more closely resemble their own capabilities. SOPHIA has clearly shown that it is possible to use artificial intelligence to design CAL programs which show some measure of understanding of the subjects they propose to teach.

B. Expert Systems.

An expert system is a computing system which embodies organized knowledge concerning some specific areas of human expertise sufficient to perform duties in a skillful and cost effective manner (Michie, 1979). Expert systems are already in use in various engineering applications. Systems like MYCIN in medicine, PROSPECTOR in mining, are examples of knowledge based systems. Expert systems tend to be useful in areas where a mathematical base is lacking. In these areas the knowledge is largely heuristic knowledge, good guesses, and good practices.

Several questions need to be understood and answered before an expert system is designed. What is the nature of the expertise? How much of it can be systematized and augmented by an expert system? What kind of presentation techniques are useful? The experience of expert system designers indicate that the private knowledge of an expert can be uncovered by simple introspection of the expert or detailed analysis of a non-expert. Often workable rules are developed by experts and system developers together. Another possibility is that the system itself can add or refine its own rules by induction (Quinlan, 1979) in the light of examples and counter examples.

The expert's knowledge can be divided into three major categories. They are personal knowledge, task specific knowledge, and technical knowledge. Each of these relate to specific types of tasks and perform certain functions. Table 4 gives some aspects of the expert editor's domain of knowledge. This table distinguishes between the editor's information base and the practical tasks for which this information is revelant. A categorization of expertise along a personal public dimension is useful because it illustrates those areas in which we can expect an expert system to operate in either a weak or a strong consultative mode.

The four possible consultative modes are:

1. User requests information.
2. System uses a continually changing menu to indicate information or procedures available.

3. System volunteers detailed information.

4. System operates automatic procedure.

Information base	Task	Consultative mode
Personal Knowledge		
General world knowledge	Query facts	none
General literacy (sensitivity to language, argument etc)	Query arguments, style etc	checklists, training packages
Tepertoire of heuristics, precedents etc	Integration of complex text structure	checklists, training packages
Task-Specific Knowledge		
Knowledge of target audience	Query vocabulary and syntax; prepare access structures	evaluation advice
Overview of text structure	Layout decisions prepare access structures	formatting advice; figure/text juxtaposition checks
Overview of task structure	Job planning and monitoring	recommended task sequences; critical decision reminds,
Memory of task specific precedents	proof correction; consistency checks	display previous decisions if consistency suspected
Technical Knowledge		
Spelling, grammar, high-agreement word usage	Copy-editing, consistency checks	display apparent errors
Printing constraints	manuscript preparation, typographic specification	alert user to specification error or inadequacy; elicit and enforce technical constraints
Copyright Law	check permissions, prepare acknowledgments	query permission status; compile acknowledgments list

Table 4. The Expert Editor's Knowledge: major categories

At level one, information available is indicated on a general index or contents list. The information provided at this level is in a generalized form. The user is expected to perceive his own needs for advice. This level is basic. At level two, the system monitors the information and ensures consistency by referring to previous decisions and task schedules. At level three, advice is made available. At level four, delegation of tasks to machines, automatic decision making, resource allocations, and other function are managed by the system.

These levels of man/machine interaction are important because they reflect a realistic view of the extent to which the process can be automated. They are also essential if the expert system is to be a learning system. From this example of an editor's information base, it is clear that the expert systems can be developed to offer aid for a wide range of tasks. The information can be included about aspects of instructional design, illustrations, typography, evaluation techniques, and so on. Many of the tasks of a human tutor can be incorporated in an expert system. However, it is less clear whether it is possible for a machine to discover meta-rules representing an expert's knowledge as to what to tackle first. Such strategic knowledge (rules), showing how the expert analyzes a complex task, may probably need to be added by the original designer.

In May 1982 the Manpower Services Commission's (MSC) training division initiated a expert systems project for training purposes in their skill center training agency. The aims of the project were:

1. To explore the potential for using computer based training in skill centers.
2. To improve the flexibility and efficiency of teaching methods and make operations more cost effective.
3. To enable the MSC to develop the ability and/or knowledge to debate the right questions and make a valid decision concerning computer based training in future skill center operations.

Evaluation of the MSC project lead to the following conclusions.

1. Producing courseware required years of practice and experience to complete.
2. Solutions were rather unreliable.
3. Experts were hard to find.

The training system developed by the MSC did not work with student feedback to build a student model on which to base future interactions. The skills training agency was able to produce training courses for various technical trades. Courseware provided an effective way of teaching the principles and diagnostic techniques of various trades such as electrical wiring and plumbing.

Several authoring languages were developed to design courseware for training purposes. Most of these authoring languages incorporated high level language structure, user friendly text editors, and an easy to use graphical interface. Most of these authoring languages employed basic interactive learning strategies to deliver the course material.

C. Adaptive Teaching Systems.:

Adaptive teachings systems employ a method of representation for investigating human problem solving domains called production systems (Newell and Simon, 1972; Howe, 1978). Production systems are designed to avoid reprogramming necessary to describe separate abilities in a particular domain. Production systems can accurately model a student's behavior in a specified task and can be used to predict a student's behavior in other related situations. The significance of this approach is that the system attempts to evaluate the decision making process by which the student arrives at the answer. Thus, the system monitors the problem solving process of the student and analyzes the student's work to monitor his progress. In this way, the student can be helped by explanations, hints, and worked examples. These systems need an explicit teaching strategy which can be altered to facilitate learning (Howe, 1978). If pupil performance is related to changes in a set of production rules which specify the goals to achieve, the selection of examples, and the student's level of knowledge, then the program's teaching strategy can be continuously evaluated and improved.

DENDRAL (Sleeman, 1975), MALT (Koffman and Blount, 1975), and MYCROFT (Goldstein, 1975) are some of the adaptive teaching systems. These systems include all the desirable properties of a human tutor described by Gable & Page, except the teacher will learn and adapt superior student methods.

D. Self Improving Systems.

Self improving systems are designed to select strategies that are appropriate to student's performance levels. The advice given to a student is based on the quality of his method of problem solving rather than the answer. Research demonstrated that for suitably structured problem solving domains, a computer assisted tutor that is capable of acquiring superior problem solving methods from the students can be designed. Examples for this system are the self improving tutor of Kimball (1982) and the self improving quadratic tutor of O'Shea (1982). These systems are able to expand their own capabilities on the basis of experience. Many people argue that unless students are given more freedom to explore their own ideas it is difficult to overcome their misconceptions. It was with this uncertainty of the fundamental value of intelligent teaching systems that learning environments were coined.

E. Learning Environments.

Building and experimenting is a valuable method of investigating many complex processes (Borden, 1977). Seymour Papert was one of the first to recognize how this area of artificial intelligence could be applied in education (Papert, 1972; Papert & Solomon, 1972). LOGO is a simple language developed to create a learning environment. LOGO encourages learning by doing and thinking about what students are doing. Students have to plan their own learning strategy, and by doing so, they learn to make their own thinking concrete. They also have opportunity to experiment and find the most efficient solution of a problem. Students should be encouraged to discuss their strategies with others. Another advantage of this learning method is that the mistakes students make lead to bugs in the programs. These bugs are not regarded as failures. Students are encouraged to regard these bugs as another problem to overcome.

Papert's enthusiasm for LOGO has convinced many teachers that the future development of artificial intelligence concepts may change the way in which students learn. However, some caution is necessary because the qualitative changes in the student's cognitive activities due to LOGO are uncertain. Other examples of learning environments are ORBIT (Di Sessa, 1975), SMALL TALK, SOLOWORKS, and PROLOG. Each of these environments have their own strengths and weaknesses. At present it is difficult to evaluate how the learning environment approach will help with the learning of school subjects where procedural thinking is necessary.

Chapter 5

Expert System Models

An expert system model can be sub-divided into expert module, student diagnosis module, and instructional or curricular module. The expert module contains the domain knowledge. The student diagnosis module evaluates the students knowledge levels. The instructional module identifies the difficiencies in the student's knowledge and selects the appropriate instructional strategies. The instructional environment and human-computer interface channel the communication between the expert system and the student.

Expert Module :

Expert modules are also referred to as black box systems. An expert module provides domain knowledge. It contains specific and detailed knowledge derived from people who have years of experience. The enormous amount of knowledge and the interrelationship of that knowledge makes the design and development of an expert module demanding and complex. The common method of encoding the knowledge into the expert module is by finding a way to encode the knowledge without actually codifying the underlying human intelligence. An expert model can be enhanced by employing a methodology called issue based tutoring (Brown, Burton, & de Kleer, 1982). In issue based tutoring, instructions are attached to the specific issues observable in both the expert and the student within the learning environment. Thus, when a student chooses or fails to choose a behavior, the corresponding feedback may be provided. SOPHIA, a sophisticated instructional environment, and STEAMER (Brown, Burton, and DeKleer, 1982; Hollan, Hutchins, and Weitzman, 1984) perform their mathematical calculations in equation solving using such techniques. These systems do not represent human knowledge, however, they produce outputs that are useful in recognizing differences between student and expert performance.

The second approach to encoding the knowledge into an expert module involves building a glass box model. This model is built using knowledge engineering techniques. A rule based representation for delivering an expert's knowledge is developed. A glass box model allows only for the explanations of an information process inheritant in the rules of its knowledge base. The rules are strategically aligned with performance rather than explanation, thus, limiting their ability in an instructional environment. However, knowledge engineering techniques are very effective tools for extraction and codification of knowledge. MYCIN utilized a glass box modeling (Buchanan and Shortliffe, 1984).

The third approach to encoding is by cognitive modeling. This modeling not only simulates the knowledge, but also simulates the way a human uses that knowledge. In order to develop a realistic cognitive model of the human problem solving process, the following questions need to be answered:

1. Which psychological components are essential for tutoring?
2. At what level should they be represented?
3. How should procedural, declarative, and qualitative types of knowledge be treated?

Procedural knowledge is knowledge about how to perform a task and is well represented in rule based systems. Declarative knowledge is fact-like and is not specialized for a particular use. Qualitative knowledge is the causal understanding that allows a human to reason about behavior using mental models of systems. One of the most challenging issues will be constructing a model that unifies and shows the relationships between procedural, declarative, and qualitative knowledge.

Student Diagnosis Module:

The knowledge structure that represents the student's current state is the student model. The process of diagnosis used to develop this model is called the student diagnosis module. Outputs from this module are used for various purposes such as advancing through selected curriculum, offering unsolicited advice, generating new problems, and adapting sets of explanations.

According to Kurt VanLehn, most programs work on the low end of the information band where only the final state is available to the system, the final state being the student's answer to the question. Access to the intermediate states enable the diagnosis module to assess the observable physical activities such as keystrokes or scratch work. The band width allows access to the learner's mental state and reasoning process. The band width is crucial for the student diagnosis module design since this module needs reliable knowledge about the student's mental state.

The second aspect of the student diagnosis module is the target knowledge type. Knowledge types can be classified into procedural knowledge and declarative knowledge. Procedural knowledge can be further classified into flat procedural knowledge and hierarchical knowledge. Each type of knowledge needs specialized strategies of interpretation. The interpretation process is more difficult to implement for a declarative knowledge type than a procedural knowledge type. Also, the interpretation process for hierarchical knowledge is more difficult than flat procedural knowledge. A flat procedural knowledge base makes the modeling process easier, whereas, a hierarchical knowledge base makes it very difficult.

Assessing student and expert is the third aspect of the student diagnosis module. Usually systems employ the same knowledge base for both expert and student. This is called an overlay method of student modeling. In this method, student knowledge is represented as a subset of the experts. Hence, missing conceptions are represented and not the misconceptions. The next level of complexity of student modeling is to represent misconceptions and incorrect knowledge. This knowledge can also be called a "bug library". These libraries are sometimes generated from bug part libraries.

Curriculum and Instruction Module:

An expert system should have three tutoring characteristics:

1. Controls the representation of the instructional knowledge for selecting and sequencing the subject matter.
2. Responds to the student's questions about instructional goals and content.
3. Implements strategies for determining the student's need for help and for delivering the appropriate help.

The goal of the instructional module is to implement teaching as a solution to the educational communication problem. The challenge in instructional module design is in separating instructional and content expertise. Types of knowledge and the nature of the learning process are interrelated. However, the interaction between content specifics and the instructional strategy is not obvious.

Most often, enabling knowledge is not represented in the expert system. It is the specific knowledge necessary for learning, but not necessary for proficient performance. Often, this knowledge comes about as an afterthought once the building process has begun. This is the danger that lies in building an expert system first and then enhancing it with explanations or instructional sequences.

The instructional module should be more than a bi-product of the expert and the student modules. Instructional principles should be robust and explicit enough to generalize across domains. Instructional theories and methodologies can help answer questions regarding the presentation of information and the presentation sequence.

Presentation techniques depend on the instructional objective. Dynamic flexibility of the instructional module depends on its ability to move from one instructional state to another. Artificial intelligence techniques can be very helpful in accomplishing this objective. Meno-tutor (Wolf and McDonald, 1985) is an example of an attempt to achieve transitional flexibility by manipulating twenty-seven interrelated instructional states.

An instructional module should have the ability to intervene, offer advice, hint or guide, and employ other strategies as needed for answering questions and providing explanations to help keep the learner on the right track by preventing inappropriate or incorrect learning. Attempts to use templates (Carbonell, 1970) or semantic networks (Brown et. al., 1982) have been tried, however, a comprehensive theory of explanation that would make automation possible has not been proposed yet.[1]

Some of the issues that are beyond the reach of an expert system design tool are; a) the design principles that determine whether a deductive or inductive reasoning approach is taken for the expert system instructional module, b) precise theories that account for instructional effectiveness and c) explicit instructional principles in particular domains.

[1] Author did not find any such explanation .

Instructional Environment:

An instructional environment consists of learning situations, activities, and tools provided by the system to facilitate learning. The trend is to provide a more creative, open, robust, fulfilling, and effective educational experience to the learner. An instructional environment should nurture constructive learning through activities-tools, games, and game worlds designed to use a student's prior knowledge, and to present students with new information and experience from which new knowledge may be constructed. The environment should emphasize conceptual learning rather than procedural learning. It should develop a means to build relational knowledge which can be applied in the real world. This environment should be self motivating, allowing effective learners to assume responsibility for their own learning.

Considerations pertaining to instructional environments are: levels of abstraction, fidelity, sequences, and help routines. Levels of abstraction represent the level of real world representation in the environment. Fidelity represents the closeness of the simulated environment and the real world. Different types of fidelity are: physical, display, mechanical, and cognitive. Sequences refer to the framework of constructs for learning complex skills. A student progresses through a sequence of increasingly complex learning processes as he achieves goals. Help routines provide additional information to learners when needed.

Human-Computer Interface:

The student working with an expert system model may not be an expert user and is attempting to learn some subject matter that is unfamiliar. If the human computer interaction is designed without due consideration to the above mentioned aspects, the training session could become unproductive and ineffective. The goal of interface design is to make the interface transparent by involving the users as direct participants in the domain by allowing them to control the domain and by instructing the system to carry out desired actions.

There are two basic styles of human interface design. First person interface also known as direct manipulation interface or iconic interface and second person interface also known as command language interface. The advantages of iconic interaction is that the students do not have to remember the names of the documents or commands. The strength of the iconic interface is its self evident properties while its weakness is extensibility. Although many of the interface technologies can help integrate the separate expert system modules, if the interface is overdone, the communication between the student and the instructional system will be impaired.

Performance measurement of expert systems:

An evaluator of expert tutoring systems must be able to articulate why they are good or bad. Designers and evaluators have not yet established guidelines on evaluating intelligent tutoring systems. These systems for the most part, have not met the requirement of the experimental method or empirical testing (Polson M.C. & Richardson J. J., 1988).

Evaluation of instructional products should include both formulative and summative evaluations. The primary emphasis of the evaluation procedure should be on formulative evaluation. Formulative evaluation takes place during the development of the system. Formulative evaluation results in corrective feedback, advice from knowledge engineers, experts and early trial users. Formulative evaluation can be classified into external and internal evaluation. External evaluation focuses on the problem solving processes. Student modeling techniques are used to identify the kinds of problems and the solving techniques. An ICS can be evaluated according to its ability to teach students the specific skills needed to solve problems. The effectiveness of the system is measured through the measurement of observable phenomena which occurs through the learning process. External evaluation makes vigorous testing possible because student modeling techniques capture how students solve problems, those techniques can be used to predict the ease or difficulty of additional problems and the knowledge necessary to solve them. The problem solving performance of the students can be compared to the predicted values.

Internal evaluation addresses the behavior questions of expert system model. It involves the analysis of various components of the expert system model. Internal evaluation should answer three major questions (Litman and Soloway, 1986).

1. What does the expert system model know?
2. What should the expert system model do?
3. How does the expert system model do what it does?

Chapter 6

Computer Assisted Individualized Instruction Model

Though gaining information is fundamental, students should grasp the provisional nature of the information and not just static concepts of knowledge and theory. Independent learning assumes the capability of systematic inquiry, self confidence, ability to find useful information, problem solving, and decision making. Systematic inquiry can be viewed as a process of categorization of available information and the investigation of missing information. Problem solving and decision making processes assume the availability of relevant information. Creativity requires a complete understanding of the activity concerned. Independent learning assumes that creativity is a prerequisite for acquiring knowledge (Litman and Soloway, 1986, pg. 241-242).

For a CAI to evolve towards an intelligent tutoring system, it must satisfy three basic tests of intelligence. First, the subject matter or domain must be known to the computer well enough to solve problems in the domain. Second, the system must be able to deduce the learner's level of knowledge. Third, the system should incorporate an instruction strategy that reduces the difference between the expert and the student.

CAI systems should be able to classify a given objective into smaller learner objectives. The CAI system should have the capability to detect the smaller objectives that are within the capability of the learner in order to position the learner in the progressive learning sequence. By positioning the learner in this sequence, it is possible to continue the knowledge building process of the learner using his internal abilities.

One of the important characteristics of intelligent tutoring systems is student modeling. This is also one of the strongest tools of a human teacher. The model should enable the information exchange of a hypothesis with students and take initiative in creating a problem solving environment where active feedback is possible in the actual logical deductive strategy of the student.

An instructional module should have the ability to intervene, offer advice, guide, and employ other strategies as needed for answering questions and providing explanations to help keep the learner on the right track. This is accomplished by preventing inappropriate or incorrect learning and initiate unlearning and relearning as necessary. An instructional environment should consists of learning situations, activities, and tools provided by the system. The idea is to provide a more creative, open, robust, fulfilling, and effective educational experience to the learner. The environment should nurture constructive learning through activities-tools and game-worlds designed to use a student's prior knowledge and to present students with new information and experience from which new knowledge may be constructed. The environment should emphasize conceptual learning rather than procedural learning. It should develop means to build relational knowledge which can be applied in the real world. This environment should be self motivating, allowing effective learners to assume responsibility for their own learning.

Human tutors learn and adapt to superior student methods. They improve and dynamically adjust the instructional process to the changing need of the students. Teachers not only learn and evolve into experts by gaining knowledge in the domain, but also solve the learning problems of students. Human teachers perform several other administrative and managerial function in addition to teaching.

A Computer Assisted Individualized Instruction model should accomplish the following objectives.

- The CAI model provides an ideal learning environment for a selected domain.
    - External conditions necessary for a successful learning environment.
    - Internal conditions necessary for a successful learning environment.
    - Domain.
        - Well defined and obtainable domain objective.

        - Instructional Strategy.
    - Student.
        - Accurate Student Modeling.
        - Dynamic feedback system that can respond and take advantage of the student model.
- The CAI model performs all the functions of a teacher efficiently.
    - Manage teacher - student interaction and classroom learning environment.
    - Classroom order, learning goals, and other disciplinary issues.
    - Different levels in cognitive functioning, personality, information processing that involves learning, memory, and moral thinking of students. Accommodating individual differences in intelligence, learning styles, motivation, and personality.
    - Humanistic learning issues such as values, self-esteem, and attitudes in a cognitive oriented curriculum.
    - Understanding and controlling the student's motivations (especially in the case of disadvantaged students).
    - Setting and using the instructional objectives and teaching for higher level objectives such as analysis, synthesis and evaluation.
    - Creativity development in students.
    - Learning and social issues concerning the gifted children and learning disabilities.
    - Student testing and evaluation.

Chapter 7

Analysis

Using the Computer Assisted Individualized Instruction model as a guide, all the benefits, advantages, short comings, and disadvantages of the cases studies, projects, models, and experiments studied in this thesis are compiled below.

Programmed instruction:

Programmed instruction has been used successfully to teach a variety of behaviors. Programmed instruction has been used in various forms such as teaching machines, flash cards, and programmed texts. Evaluation of programmed instruction examples using the Computer Assisted Individualized Instruction model is inappropriate. However the vision of pioneers of programmed instruction to use man made machines to replace human teachers could very well be within reach, if the Computer Assisted Individualized Instruction model is practical.

Computer aided instruction:

Internal learning conditions include computer literacy, prerequirements, social, emotional, family, and other conditions. External learning conditions include issues such as school policies, procedures, student's and staff's computer literacy, system access, hardware and software quality.

Results of PLATO, RHIEO, and other CAI studies and experiments, and case studies indicated that CAI systems failed to control the external and internal conditions conducive for learning. With organized lessons and activities, when teachers integrated CAI systems into the class curriculum efficiently, they performed well as drill and practice tools and saved classroom time for concept development and individualized instruction. However concept development and individualized instruction remained a function of the teacher. When teachers were not motivated or failed to fully integrate the CAI systems into curriculum, CAI systems performed poorly.

PLATO, RHIEO, and other CAI studies and experiments, and case studies indicate that CAI systems could not handle human and social aspects of learning. Human emotions such as enthusiasm, attention and concentration was intense during the initial CAI sessions. The ability of CAI to maintain the attention, concentration and enthusiasm of the children remained questionable.

CAI systems could not effectively deal with issues such as emotion, anxiety, and exhaustion. Students who were nervous, self-conscious, and who had difficulty with drills found that CAI was exhausting. Another social effect of CAI was competition. Competition appeared to vary across schools, classrooms, sub groups and individuals. Competition took several forms. The spirit of competition was at times strong and struggles to win were observed. However, competition appeared benign. Visibility and recognition of accomplishment were also high.

These studies indicated that CAI systems have the potential to motivate and control the behavior of children. They sometimes served, in part, as a reward for good behavior in the classroom. Sometimes CAI systems provided a special private space for some children and gave an opportunity to learn in a non-threatening atmosphere and at the same time be rewarded with instant feedback. In almost all of these studies and experiments CAI systems were used as a tool and not as a stand alone instruction system.

From observation, it was evident that field testing a prototype lesson was a very labor intensive undertaking. Prototype lesson design, development, field testing, and revision usually consumed significant amount of the teacher's time. These studies also indicated that use of CAI resulted in some structural and procedural changes in teaching practice in certain domains such as language instruction. Teaching practices also shifted more towards individualized instruction while CAI systems were in use. The teacher's classroom role shifted towards being a resource provider and a counselor. As a resource providers they monitored, self-paced, and individualized instruction and as a counselor they solved learning problems of individual students.

It is also observed that achievement and efficiency were not generally affected by allowing students to control the sequence or amount of their instructional components. Of all the student characteristics investigated, only aptitude and the capability of self-assessment seemed to interact with learner control. The TICCIT study indicated that study patterns differ significantly according to the subject matter.

Intelligent tutoring systems, expert systems and knowledge based systems:

Intelligent tutoring systems, expert systems and knowledge based systems maintained a certain degree of control over internal learning conditions. However most of the external conditions are controlled by the teachers and administrators. Most intelligent tutoring systems, expert systems and knowledge based systems, attempted to profile successful tutors. Since the presentation of information was more learner driven, the focus of the systems was to guide the student through the learning process. Though this concept is theoretically true, it is very difficult to implement.

One of the important characteristics of intelligent tutoring systems is student modeling. Most of these systems enabled student interaction with the system. This information exchange of hypothesis helped create a problem solving environment where feedback was actively used in the actual logical deductive strategy that the student would use. In general, these programs attempted to discover the fault or defect in the student's thinking or understanding and offered appropriate tutorial advice.

Some of the intelligent tutoring systems, expert systems and knowledge based systems included very efficient and accurate student models. However most of these systems did not attempt to evaluate the student responses or help the students to overcome misunderstanding or misconceptions by analyzing the responses. Thus these systems, to a varying degrees, failed to rectify one of the drawbacks of frame oriented CAI.

The challenge in instructional module design is to separate instructional and content expertise. Types of knowledge and the nature of the learning process are interrelated. However, the interaction between content specifics and the instructional strategy is not obvious.

Some of the instructional modules of the expert systems and knowledge based systems were able to intervene and employ various strategies as needed to keep the learner on the right track by preventing incorrect learning. It was not clear whether it would be possible for a machine to discover meta-rules representing an expert's knowledge as to what to tackle first. Such strategic knowledge (rules), showing how an expert analyzes a complex task, was incorporated by the original designer or knowledge expert.

There are no indications in the systems studies that they have the built in ability to learn from students, identify creativity, or recognize new patterns of a learning process.

These systems generally evaluated the decision making process by which the student arrived at the answer. Thus, the system monitored the problem solving process of the student and analyzed the student's work to monitor his progress.

It is also observed that CAI systems performed better when instructional domains were narrower. In addition, the performance deteriorated and became irregular as the domain broadened. In general, CAI systems performed progressively better as the domains became increasingly objective.

The main benefits and concerns of computer aided instruction as observed can be summarized as follows.

- CAI systems helped students taste the pleasures of learning.
- Enhanced knowledge retention by hands-on application of it.
- The computer is a good tutor patient and never looses its temper, and never lets the student get away with misunderstood concepts.
- Putting kids in-charge of their learning environment, while teachers become facilitators, did not seem to produce more effective learning.
- Better and stable hardware and technology did result in increased acceptance and adaptation but there was no evidence that technology itself improved learning.
- Good quality software, lessons, and programs were not readily available and development of lessons was labor intensive.
- It is difficult to determine if students were reading the information in the monitors and using it or looking at the picture and playing the learning game and not reading or understanding.
- There was no interaction between teacher and students.
- Danger of control in the hands of the uninformed (student).
- Danger of abuse of technology.
- The computers are not committed to self development, learning, or innovative. The CAI system fared badly in the aspect of creativity. Teachers self develop, evolve, innovate, and learn as they adapt to the demands of teaching. Teachers can think, solve problems, develop, derive, discover, invent, and innovate. A computer's ability to do these functions is highly limited.
- Students tend to learn more practical knowledge. But whether computers can bridge the gap between information and knowledge is a question not answered.

Chapter 8

Summary

The educational system empowers the child to realize success in school. Empowerment was facilitated by including the child's culture and linguistic characteristics in the curriculum and instruction. Otherwise the educational system would become an impediment to the child by not including those characteristics. Ultimately education should prepare an individual to be an asset to the society. Education should also equip and enable an individual to be creative, inventive, innovative, and productive.

Teachers themselves could either teach in a reciprocal or interactive mode whereby students could become active participants in their education, or be passive as teachers merely lecture. Learning comprises of the information that is absorbed, its patterns and the perceptions of an individual's mind. The meaning of a specific message is clear when the relationships of the contents within are understood. Information is contained in the pattern and the interpretation of the pattern is determined by the program. This process is the result of learning.

The analysis indicates that, given all favorable conditions such as a narrow domain, all the necessary initial conditions, and external conditions; there are several CAI systems that can achieve effective learning. However this thesis identified several areas where definitive solutions are hard to find.

Education has several social, emotional, moral, and cultural implications. A student's academic progress greatly depends on his emotional and social progress or development. Not surprisingly, this thesis has not find any system that was able to address these issues successfully. Another question that was not answered definitively is about independence or self directed learning. How much freedom is productive? Can students be allowed to take over the complete responsibility of the learning process? This thesis found that almost all successful CAI endeavors that had effective teacher participation were successful at least as far as learning is concerned.

The author came to a conclusion that an efficient counselor/facilitator is essential for successful individualized computer assisted instruction. However the author believes that the role of the counselor is to provide guidance and assistance in the issues of physiological learning while a well designed and implemented CAI system performs the individualized instruction. The involvement of the counselor varies with the abilities, needs, and limitations of an individual student. While the bulk of the routine instruction, concept development, drill and practice work is managed by CAI systems, teachers could assume the roles of counselors and experts to give special attention to the needs of students.

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APPENDIX - A

LEARNING THEORIES

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Learning Theories

The roots of programmed instruction are deep both in the theory of education and in psychological learning theory. Five hundred years ago Comenius tried to specify a kind of education that would cause a student to learn more and the teacher to teach less. Pavlov, Thorndike, Hull, Guthrie, and many others have demonstrated how a human or a laboratory animal could be conditioned to respond to a given stimulus and how a secondary reinforcer could be substituted for a primary one.

Good teaching begins with a meaningful educational problem. Programming is a form of communication which is used to teach a body of data (curriculum) to the students. The nature of the educational problem determines the importance of each basic factor that influences the program development and program effectiveness.

A. Basic Considerations:

The Student: Students are one of the most important factors that influence the program development and its implementation methods. The student's age, cultural background, previous experience, education, training, motivation, personality, learning and thinking style, social and antisocial behaviors and the student's expectation influence the program development and its success.

The Desired Result: It is essential that a program has a definite learning objective. The learning objective includes detailed curriculum, expected skills or knowledge, and the knowledge of its use. That is, the program should know about the subject (English Grammar) it tutors. The student's learning needs and requirements with regards to the subject (spelling, pronunciation, oral comprehension, reading ability ...), and the area of application of the knowledge (scientific or general cultural activities). Each of these issues will limit or expand the problem. Usually the desired end result will determine the type of program and the instruction methodology.

The Curriculum: The characteristics of the subject usually determine the instructional method that can be adopted effectively. That is, the characteristics of literature and mathematics are so different that they cannot be taught in a same manner.

Other factors that influence the program development and its methods are content, order of presentation, teaching methods, cost, program style and hardware considerations. Successful instructional process takes into consideration all these basic factors.

B. Learning Theories:

Learning is a change in human disposition or capability that can be retained, and is not simply ascribable to the process of growth. Learning exhibits itself as a change in behavior. The behavioral changes resulting from learning could be increased capability for some type of performance, or altered disposition of characteristics such as attitude, interest, or value. The presence of the performance by itself cannot conclude the occurrence of learning, a change in performance is necessary. Learning can be measured by comparing behavioral changes in the student before he was placed in a learning situation and after he completed the such process or exercise. This behavioral change in the human attributes due to learning must be permanent and not temporary. It must be distinguishable from the kind of change that is attributable to growth. The change in performance is what leads to the conclusion that learning has occurred.

One of the oldest lines of thinking about learning is primarily concerned with the question of construction of complex ideas in the human mind from elementary sense impressions. These theories generally agree that acquiring a new idea necessitates contiguity of sense impressions and repetition of these contiguous events. Some theorists discuss attention as an important condition for learning by association.

1. Thorndike's and Skinner's Reinforcement Theories:

Edward L. Thorndike (1898), was a pioneer in the efforts to understand the learning of animals. His investigation suggested the possibility of a specific bond between "sense impressions" and "impulses to actions" that explain animal learning. Thorndike believed that the associations resulting from the consequences of completed acts contribute to learning. Thorndike summarized that when confronted with a novel situation, the motivated learner engages in various "tries" to attain satisfaction. The particular responses that lead to motive satisfaction become stronger in relation to others. In the subsequent trials, the "errors" progressively weaken and disappear. The correct responses are progressively strengthened by being followed by motive satisfaction. This generalization was called "law of effect" by Thorndike. Skinner used the term "reinforcement" to identify the same events (Gagne 1964).

Edwin R. Guthrie (1935), Clark L. Hull (1943), and B.F. Skinner (1938), adopted individual association between stimulus and response seen in animals as the basis of their ideas on learning. However, each of them proposed a somewhat different interpretation of the basic idea. Edward C. Coleman (1932), was one of the investigators of animal learning that opposed this tradition. Coleman's theory maintained that association was an internal matter between a representation of stimulus situation and a representation of the alternatives of action to be taken. Thus he attempted to restore to animal behavior the "idea" that had been considered unnecessary.

2. Pavlovian Conditioning Theory:

The learning process includes a complex mixture of conditioned and unconditioned responses. Pavlov, I. P. (1927) found that when a new signal such as a buzzer sounded at the time food was shown to a hungry dog, and this set of events was repeated several times, the dog came to salivate at the sound of the buzzer alone. Salivation at the sight of food could be considered a natural or unconditioned response. Whereas, salivation to a buzzer sound is acquired as a conditioned response. Though common, most of the learning events are not based on conditioned responses (Gagne 1964).

Most investigators of Pavlovian conditioning believe that "anticipatory" responses such as the startled eye-blinking that may follow a threatening gesture are a part of a very special kind of learning (Gagne 1964). Voluntary acts can be conditioned with difficulty, if at all possible. If a child wants to learn to ride a bicycle, he will get no help in this activity by arranging the pairing of conditioned and unconditioned stimulus, because voluntary control of his actions is not acquired in this way. The same is true for most other kinds of learning such as, reading, writing, and arithmetic.

3. The Learning of Verbal Associates:

Hermann Ebbinghaus (1913), carried experimental studies of learning and memorization using nonsense symbols. These constructed symbols were employed in an attempt to gain control over the unwanted variable of previous practice. Using these experiments, Ebbinghaus studied the effects of such variables as length of series, order of presentation, and many others. Later, Robinson (1932), McGeoch (1942), Melton (1940, 1964), Underwood (1964), Postman (1964), and many other investigators saw the nonsense symbols as a versatile tool for the study of verbal association.

Ebbinghaus's results showed that committing one syllable to memory was strongly influenced by the presence of other syllables. The learning of any single association in a sequence has been shown to be affected by the interference of other associations both within the list and outside the list. Many characteristics previously thought to describe the learning of single associations are now attributed to the effects of interference.

The verbal associate prototype must also be considered to represent the very limited range of actual learning situations. The differences in learning and retaining logically connected prose and poetry as opposed to nonsense lists has been apparent for many years (Ausubel, 1963), and it is doubtful that the interference that occurs within these two types of material follow the same laws. There may be a limited number of instances in which human beings engage in the learning of material whose members are arbitrarily related, as in learning the alphabet. But, the majority of verbal learning that occurs must be affected strongly by its meaningfulness, as experiments on verbal associates have demonstrated.

4. Gestalt Conditioning Theory:

The Gestalt conditioning theory, as reflected in the writings of Max Wertheimer (1945), Wolfgang Kohler (1929), and Kurt Koffka (1929), is that learning takes the form of an insight. An insight is a suddenly occurring reorganization of the field of experience, as when one "has a new idea" or "discovers a solution to a problem". Kohler used a variety of problem situations to study insightful learning in chimpanzees. He emphasized the behavioral discontinuity chimpanzees had with the previous trial and error behaviors. The totally successful act was put together and exhibited suddenly, without error and as if by plan. Kohler interpreted this insight as sudden realization of relationships, and the internally represented relationships between events (Kohler, 1929).

The insightful learning in human beings was described by Max Wertheimer (1945) and Katona (1940). An insightful learning in human beings occurs when the student recognizes or understands the essential structure of the problem situation. Most frequent criticism of the insight explanation of a learning event is that problems are solved by transfer of knowledge from previous learning. Despite the neatness of the theory that accounts for insight on the basis of the structure of the observed situation, the phenomena of insight has been consistently affected by previous learning. As evidenced in Harlow's 1949 studies of learning set, previous learning acquired through a number of encounters with similar problems can establish an internal capability that is different from the subjects who have not experienced the same situations. This capability of insight did not arise because of a "structuring of the situation". It came from accumulated experience based on many individual trials of previous learning.

The insight appears to represent some common learning occurrences that are rather easy to identify. On the other hand, it is difficult to find insight in the learning of a great variety of other things, e.g. a child cannot learn the names of plants or stars in an insightful manner, or learn to read by insight, or learn to speak a foreign language. This goes to say that insight cannot be a prototype for a vast amount of learning that human beings ordinarily undertake. Perhaps insight occurs when we learn by "solving problems". Many things that are learned are not problems. They may be facts, propositions, or principles.

C. Learning Prototypes:

The conditioned response, the learning of verbal associates, and insight are the most popular prototypes that represent a variety of learning (Gagne 1964). There is no evidence to prove the superiority of one prototype over the other. In addition, there are many instances of learning that these prototypes do not explain adequately.

The naturalistic viewpoint of learning classifies learning into eight kinds. The traditional prototypes represent only part of the situations in which learning occurs. The kind of questions to be answered by a generic learning prototype are:

1. The conditioned response prototype is used to account for the fast alerting reaction of an automobile driver to a flashing red light. What about the subsequent actions requiring skilled control of the car?
2. An infant's first words may be acquired as simple associations. Is it possible to understand how the child learns to construct meaningful sentences?
3. A traditional prototype may be used to represent learning the name of a particular dog. Can one also account for the differentiation of dogs and cats?
4. Learning the names of the numerals 7, 8, and 9 can be represented by a simple learning prototype. How does an individual learn to use these numerals as numbers to express quantities?
5. Verbal association can represent the memorizing of a particular expression of Newton's first law. Is it possible to understand how an individual learns to apply this law?
6. Insight is often used as a prototype for the solution to a mathematical puzzle. How does a learner acquire knowledge of the structure of mathematics?

All these human activities, listed above, are learned. The proper classification of these examples is necessary to understand the conditions of learning.

1. Conditions of Learning:

(i). Internal Conditions:

Most of the traditional learning prototypes belittle or ignore the existence of prior capabilities of the learner. And these prior capabilities are of crucial importance in distinguishing the varieties of conditions needed for subsequent learning. The presence of the prerequisite capabilities of the learner often determine the success of the learning experience.

(ii). External Conditions:

Different external conditions are essential for learning different kinds of capabilities. For example, assuming all prerequisite capabilities, learning an English equivalents of ten foreign words and learning how to multiply two negative numbers would require different external conditions.

(iii). Educational Implications:

Identification of prototypes of learning in terms of conditions that produce them have some definite implications for education and educational practices. These implications are related to educational procedures adopted in each prototype of learning. The requirements for efficient learning determine the features of an educational process.

(iv). Limitations of Learning Implications:

Applying the principles of learning cannot solve all the problems related to education. Aspects of personal interaction between the teacher and his students include motivation, persuation, and the establishment of attitudes and values. The development of these human dispositions is a very importance aspect of the educational system. In other words, a learning system should incorporate learning of motivations and attitudes. The scope of this theory is restricted to intellectual or curriculum content that leads to improvement in human performances.

Another limitation of this theory is that it does not establish the highest levels of human performance or know how to continue the learning process to its highest level. At present, this theory does not specify all the conditions necessary to attain the highest and most complex level of human performance, such as those displayed in invention and esthetic creativity. Understanding how learning occurs in every situation is valuable, but it does not answer all the mysteries of education.

(v). Planning for Learning:

Planning needs to include the student's capabilities before and after the learning situation. Careful determination of all the specific prerequisites for the learning situation is essential, and the learning objectives should be clearly defined.

(vi). Managing Learning:

Learning conditions also have implications for the management of learning. Some of the management issues of learning are the student's level of motivation, interest, effort, guidance of his effort, and accurate assessment the outcome.

A student by himself cannot perform these functions. These functions are among the most important functions of a teacher. These functions of learning management are essential for accomplishing learning in an effective manner. They are required regardless of the conditions of learning.

(vii). Instruction:

Instruction is an activity that is at the heart of the educational process. Instruction arranges the conditions of learning that are external to the learner. One aspect of instruction is knowledge transfer. Ideologically, education should be concerned not only with the acquisition of knowledge, but also with the use and generation of it. The knowledge transfer cannot occur if the knowledge has not been initially mastered. But, beyond the initial mastery of the knowledge, the conditions of instruction that are conducive to knowledge transfer are very important.

The learning conditions essential for instruction are constructed in stages. At each stage, due consideration is given to previously acquired capabilities of the learner, requirements for retention of these capabilities, and specific stimulus situation needed for the next stage of learning. Instruction may be pre-designed (e.g. textbooks, workbooks, programmed instruction or teaching machines), or extemporaneously designed by a teacher, or verbally communicated with the student. All these events are instituted for establishing the proper external conditions for learning.

For a number of reasons, the instructional mode of group discussion appears to be well designed to accomplish knowledge transfer. Properly led group discussions not only stimulate the production of new extensions of knowledge, but also provide a convenient means of critical evaluation and discrimination of ideas.

(viii). Media of Instruction:

The required conditions for learning can be put into effect in different ways and in different mediums. Some media are more adaptable for instructional purposes than others. Each instructional media has its own positive characteristics and limitations in the light of their learning functions.

2. Classification of Learning:

The prototypes of learning are distinguishable from each other in terms of conditions required. The components used in discussing the prototypes of learning are stimulus situation represented by S, set of responses represented by R, and the inferred connection between them, shown by a set of connecting lines. The input is a stimulus situation, S, which includes a variety of changes in physical energy that reach the learner through his senses. The stimulus situation is outside the learner and can be identified and described in terms of physical sciences. The output response, R, is also outside the learner. The input may be a slide image, a shape, an object and the output may be a wave of the hand, a movement, a nod, or a spoken word, or written word.

The nature of the connection between S and R cannot be directly observed. Studies of nervous systems may someday provide a much greater understanding of these mechanisms. It is necessary, however to make some immediate inferences about the kind of transformation that must occur. To speculate about how such mechanisms work would be to construct a theory, as Pavlov, Hull, and other investigators have done. The immediate inference, that is based on observations of learning, indicate the capability of the learner that exists following the events of learning which was not there before. A simple example is: a reflex is the inferred capability one is accustomed to make in describing the transformation between a light shining on the retina (S), and a pupil contraction (R). Such a transformation is represented in the diagram below.

S ------ R

Light Pupil contraction

3. Types of Learning:

(i). Signal Learning:

Signal learning can be described as the individual learning to make a general, diffuse response to a signal. This is the classical conditioning response of Pavlov (1927). Learning to respond to a signal is a learning quite familiar to everyone (Guthrie, 1935). For example, two small town boys who lived before the day of the rural use of motor cars had their Friday afternoons made dreary by the regular visit of their pastor, whose horse they were supposed to unharness, groom, feed, and water and then harness again on his departure. Their gloom was lightened finally by a course of action which one of them conceived. They took to spending the afternoon of the visit retraining the horse. One of them stood behind the horse with a hay fork and periodically shouted "Whoa" and followed this with a sharp jab with the fork. Unfortunately extra records of this experiment were not preserved, however the boys were quite satisfied with the results. This is the description to a set of conditions appropriate for the establishment of a conditioned response and is represented as follows:

$$\mathbf{S} \rightarrow \mathbf{R}$$

"Whoa!" Pain Response

The conditions for the establishment of this form of learning are:

1. The stimulus producing the desired result is established.
2. The stimulus is providing the signal.

The number of instances of this pairing that must occur before learning takes place is not known. The important characteristic of this type of signal learning is that the responses are general, diffuse, or emotional. This learning has a truly "involuntary" character and it applies to responses that are not under voluntary control (Kimble, 1961). A fear response to a involuntary, general, and diffuse activity includes speeded heartbeat, constriction of blood vessels, and other internal involuntary behavior, which may readily acquire a connection with a signal under similar conditions.

(ii). Stimulus-Response Learning:

In stimulus response learning, a student acquires a precise voluntary response to a discriminated stimulus. The student learns a connection (Thorndike, 1898) or a discriminated operand (Skinner, 1938), which is also referred to as an instrumental response (Kimble, 1961). This type of learning involves making very precise movements of the skeletal muscles in response to very specific stimuli or combinations of stimuli. Stimulus response learning helps individuals learn to perform actions when desired. The response acquired by stimulus response learning is a fairly precise and circumscribed skeletal muscular act. Stimulus response learning is different from the generalized emotional responses that characterize the Pavlovian kind of signal learning. Attempts to establish signal learning by means of sequences of events similar to that described for stimulus response learning have been unsuccessful (Kimble, 1961).

The important conditions necessary for the acquisition of stimulus learning are a gradual learning process, a "shaping" response to the stimuli (Ferster and Skinner, 1957), precision control of the stimuli, and a reward or reinforcement for the correct responses. Generally, several repetitions are required to establish the capability.

The capability acquired in a stimulus response learning situation suggests a differential characteristic of learning. That is, a particular **S → R** relationship is established through stimulus learning, while other equally probable relationships **(S → Rs)** are disestablished. This can be shown by using an arrow to emphasize the process of discrimination. Another characteristic of stimulus response learning is that it is motor learning. An important component of the stimulus is generated by muscular movement. While the act is being established, the external stimulus is accompanied by proprioceptive stimulation. Even when the act is fully learned, some parts of the stimulation are still present. E.g. teaching a dog to "shake hands." Stimulus response learning can be represented as follows.

$$\mathbf{Ss \rightarrow R}$$

S refers to external conditions, suffix "s" corresponds to the accompanying internal proprioceptive stimulation.

(iii). Chaining:

Chaining is a simple and widely occurring learning situation. Chaining involves combining or connecting two or more previously learned stimulus response relationships in sequence **(Ss $\rightarrow$ R's)**.

A simple example of chaining is that of a child learning to ask for a specific object by name. After a number of parental tries, the child appears to acquire such a capability suddenly and without there being a clear relationship between the child's calling for a doll and the events that have happened before. Growth factors need to be accounted for this success. First, the child learns to ask for a doll by learning to make a verbal response. This learning can be classified as stimulus response learning. The sight and feel of the doll accompanied by the spoken word "doll", becomes the stimulus situation. This stimulus response sequence can be represented as:

Ss$\rightarrow$ R

doll doll

Another **Ss $\rightarrow$ R** is the child picking up the doll, handling it, and hugging it, shaking it and so on. Thus in a nonverbal sense the child knows what a doll is. This can be represented as:

Ss $\rightarrow$ R

lying down hugging doll

If both **Ss $\rightarrow$ R** connections are present, the chain of asking for a doll can be learned in a relatively simple manner. The conditions necessary for a chain learning to occur are:

1. The individual links in the chain must be previously established.
2. There must be contiguity of each link with the following link.

3. When the two previous conditions are fully satisfied, the acquisition of a chain appears to occur on a single occasion.

(iv). Verbal Association.

Verbal association is the learning of chains that are verbal (Underwood 1964). This type of learning can be classified as a sub-variety of chaining. Verbal associations have some unique characteristics and have a distinguishable set of learning conditions. The conditions necessary for verbal association learning are as follows.

1. The **Ss** $\rightarrow$ **R** connection that associates the word match must have been previously learned.
2. The **Ss** $\rightarrow$ **R** connection that enables the individual to associate the key symbol with the response must have been learned. In other words, response differentiation must have previously taken place. The learner must know how to say the word accurately to be considered correct.
3. The coding association of the image and the word must have been previously learned. The selection of this code by the learner depends on his own previous history.
4. The chain must be sequential so that each **Ss** $\rightarrow$ **R** is contiguous in time with the next.

(v). Multiple Discrimination:

The individual learns to make a number of different identifying responses to as many different stimuli. Both stimuli and response may resemble each other in physical appearance. Although the learning of each stimulus response connection is a simple stimulus response learning, the connections tend to interfere with each other's retention (Postman, 1961).

The learning of a single relationship **(Ss $\rightarrow$ R)** and the learning of chains of relationships **(Ss $\rightarrow$ R)** represent fairly simple events as long as each instance of learning is carefully distinguished and insulated from other instances that may tend to occur at the same time or from other instances of similar occurrence at different times. People tend to forget what they have learned. This characteristic is counter balanced by its ability to relearn and forget what was learned and stored. That is, short chains are easy to learn, but hard to retain. Increasing the number of relationships to be learned does not change the basic nature of the learning process, but it highlights the effects of forgetting.

The conditions for learning multiple discriminations are as follows:

1. Individual relationship chains connecting each distinctive stimulus with each identifying response must be learned. That is, the individual relationships **(Ss $\rightarrow$ R)** that differentiate the stimuli and the response names must be previously learned.
2. Measures must be taken to reduce interference to ensure retention.

(vi). Concept Learning:

Concept learning appears to be critically dependent on internal neural processes of representation. In humans, this function is served by language. Humans are highly inclined to internalize their environment to manipulate it symbolically and to think about it in endless ways.

Learning a concept involves learning to respond to stimuli in terms of abstract properties like color, shape, position, number, as opposed to concrete physical properties. Concept learning helps the learner to identify a class of objects that differ from each other physically. This identification is intuitive on the basis of an internalized representation. The learner acquires a capability of making a common response to a class of stimuli that may differ from each other widely in physical appearance. The learner is able to make responses to a entire class of objects or events (Kendler, 1964).

The conditions for concept learning are:

1. The stimulus portion of the chain that is used to differentiate objects of a class must be previously learned.
2. In order to understand the conceptual property in its internally represented form, all the stimulus conditions represented in the property must be learned.
3. The learning of a new concept may be a gradual process, since the process of discrimination of all stimuli and response is necessary to accomplish the learning of the internal representation of the process.

(vii). Principle Learning:

Principle learning is a chain of two or more concepts. Principle learning helps to control behavior in a manner suggested by the verbalized rule of the form; "If A, then B", where A and B are concepts.

If a learner is able to demonstrate the ability to use the principle in a number of instances, then it is justified to conclude that he has learned the principle. The principles of linking are same as that of chaining(type 3), except that internal representations of concepts being linked together rather than the relationships **(Ss → Rs).**

The concepts that link to form the principle must be previously learned. When a principle is to be learned, the learner must have understanding of the concepts that form the principle. When all the concepts are already learned, the process of chaining is simple. Generally under these conditions, the learning of a principle takes place on a single occurrence.

Some writers have suggested that principles need to be discovered. That is, the examples of the principle be presented, and the learner is left to do his own chaining. There is no evidence that this is a better method of learning. When learning conditions are fulfilled, telling the principle to the learner is much quicker than any other method and may well be most effective (Ausubel, 1963). The danger of using verbal statements lies in the possibility that only verbal chains will be acquired rather than true conceptual chains. When concepts are not understood and learned, the learner may react to the verbal statement as a verbal chain to be memorized. This would result in ineffective instruction.

(viii). Problem Solving:

Learning to solve problems requires an internal event called thinking. Two or more previously acquired principles are somehow combined to produce a new capability that can be shown to depend on a "higher order" principle.

Once principles are acquired, the learner can use them for many purposes. The learner is able to combine the principles he has learned into a greater variety of higher order principles. This may be accomplished by self-stimulation, thinking, and also by responding to various forms of stimulation from the environment. By the process of combining old principles into new ones, the learner learns to solve problems that are new to him. Thus he acquires greater capabilities. Problem solving means thinking out a new principle that combines previously learned principles. The number of conditions that are apparently essential for problem solving are as follows:

1. The learner must be able to identify the essential features of the solution before he arrives at it. This condition is important because of the lengthy chains involved in problem solving.
2. Relevant principles must have been previously learned.
3. The recalled principles are combined to form a new principle and this process of forming new principle results in learning. At this stage, the nature of linking

principles, degree of complexity, and logical steps involved in this process are not known. The intermediate responses made by the learner are the outcome of his thinking.

4. The individual steps involved in problem solving may be many and the entire process may take time. However, the solution is arrived at suddenly. Repetition has little to do with the problem solving process nor it is a powerful factor in the prevention of interference or forgetting. A higher order principle that results from thinking appears to be remarkably resistant to forgetting.

Problem solving results in the acquisition of new ideas that multiply the applicability of principles previously learned. As in the case with other forms of learning, its occurrence is founded on the previously learned principles. Learning by problem solving leads to new capabilities. It not only results in higher order principles, but also leads to strategies that serve to determine the direction of thinking, and its productiveness.

Through the years there have been investigators who believed that learning is basically the same (Thorndike, 1991). Each variety of learning begins with a different state of conditions and ends with a different capability for performance. Hence, it is safe to assume that the differences in these varieties of learning far outweigh their similarities (Gagne, 1965). The most important class of condition that distinguishes one form of learning from another is its initial state. This generalization applied to the above discussed learning types as shown in Table 5.

This can be represented as:

Type 8 → Type 7 → Type 6 → Type 4 or Type 3 → Type 2

<u>Problem Solving</u> requires as prerequisites;

↓

<u>Principle Learning</u> requires as prerequisites;

↓

<u>Concepts Learning</u> requires as prerequisites;

↓

<u>Multiple Discriminations</u> requires as prerequisites;

↓

<u>Verbal Association</u> or other <u>Chain Learning</u> require as prerequisites;

↓

Stimulus Response Learning.

Table 5: Generalization of the Learning Types.

D. Learning and Content of Instruction:

Learning conditions establish a capability in the learner that is consistent with those conditions. This capability may be specific to the kind of competence attained in principle learning and problem solving. But in all cases, the capability embodies some identifiable content. Learning in humans occurs in the form of a change in behavior that can be described in terms of an observable performance. A successful act of learning is inferred from the fact that the learner can now do something he could not do before. The content of capability with which the learner begins as well as the content with which he ends are both essential for this inference.

E. Planning Sequences of Instruction:

The existing capabilities within the learner that build on each other provide the possibility for the planning of sequences of instruction within a given content area. It is possible to work backwards from any given objective of learning to determine the prerequisites of learning. Such an analysis of learning objects would result in a road map for the learning objective. Within this map, many alternate routes are also available for achieving the desired objective with destination.

This method of mapping the sequence of learning enables one to avoid mistakes that arise from skipping essential steps in the acquisition of knowledge of a content area. This is where CAI should develop itself to a point where a given objective can be classified into smaller learner objectives. The CAI system should have the capability to detect the smaller objectives that are within the capability of the learner in order to locate the learner in the progressive learning chart or sequence. By locating the learner in this sequence, it is possible to continue the knowledge building process within the learner using his internal abilities and other conditions.

F. Description of Learning Content:

The contents of learning are often referred to as large categories of subjects such as English and mathematics. Although these categories may have a certain usefulness as entities of planning, these categories are so large that each includes a considerable variety of different kinds of human performances. The existence of such categories makes it difficult to determine what human capabilities these categories should include. Another unfortunate consequence of subject categories is that they tend to engender a belief in their reality apart from their component human competencies. Thus, the false belief of English as a content for learning involves more than being able to read, write, and speak.

Mathematics involves more than learning to solve problems logically and quantitatively. This problem of subject categories can be avoided by emphasizing the attainment of the learners.

Some of the learning structures for curricula subjects are described below. It is necessary to break the curricula into smaller units of student competencies. Since these units do not necessarily correspond to the topics into which a subject is usually divided, a certain degree of novelty can be expected. However, they do make it possible to state the relationship between the content of instruction and the requirements of learning conditions.

Learning Structure in Mathematics:

The phases of learning structure in mathematics are described as follows:

Phase 1: Stimulus response learning: Children learn to say the names of numbers from 1 to 10 and beyond. They learn other technical words such as multiply, cube root, etc.

Phase 2: Chaining: Nonverbal chains include printing of letters and symbols and drawing of geometrical forms.

Phase 3: Verbal Sequences: Many kinds of verbal sequences are important and fundamental to mathematical learning. Some of the verbal sequences are counting numbers, vocalization of printed numerals, etc.

Phase 4: Multiple Discrimination: The fundamental discriminations permit the learner to differentiate one specific object from the other. For example the ability to differentiate 1 from 2, 2 from 3, etc. The only multiple discrimination that is assumed essential in formal instruction on numbers is the difference between nothing and one, and between one and two. Another basic set of multiple discriminations that must be acquired early are the distinctions between printed numerals and other symbols. Some of the discriminations are a potential source of difficulty if they are not mastered. Some of these discriminations include positions of coefficients, the exponent, and the subscript, parenthesis and brackets, separations and intersections, and the extents of angles.

Phase 5: Concept learning: Alike and different are two concepts that are essential to later learning in mathematics. Learning these two concepts means being able to say about any objects, pictures, or symbols that they are alike or different. Another fundamental concept of early instruction in numbers is a set. A set is the concept of quantity abstracted from a variety of groupings of specific objects. One of the earliest objectives of mathematics instruction is the acquisition of the concept a set by the student. The concept of the member, the single unit of a set, needs to be acquired even earlier. After a learner acquires the concepts of a set and member of a set, he is able to generalize them to other objects. In combination with the previous learning of verbal associates, the learner will be able to assign names to such sets. There are several other simple concepts involved in early mathematics instruction. The concept stage of learning is an essential one and should not be skipped over in instruction.

Phase 6: Principle Learning: The intention is to teach the learner to count and to add by acquiring principles. Having the concept of set, member of set, adding to, and taking away from the set, makes it possible for the learner to acquire principles. The sequence of learning is somewhat as follows: The set called 2 is formed by adding a member to the set 1. The set called 3 is formed by adding a member to 2; and so on. Once acquired, these principles will help the learner to count numbers. Mathematics is full of principles and they build on each other in cumulative fashion.

Phase 7: Problem Solving: Principles can also be learned in mathematics by a judicious use of the discovery method of instruction. For example, having learned the counting methods, the learner can be led to discover the principles governing the place of numerals as a means of naming sets 10 - 20, and thus begin to learn the decimal system.

G. The Order of Learning Types:

These examples from mathematics provide an answer to the question of sequence in forms of learning that should be followed during instruction. But this kind of sequence can be applied to individual topics only. It would be incorrect to assume that the learning of all mathematics begins with stimulus response learning and progresses through various other types of learning leading to problem solving. There is no rule that multiple discrimination and problem solving cannot occur early in the elementary topics or in advanced topics. However, within a topic there is a progression of learning types from simple to complex. Principles to be learned are put together in the form of a progression from prerequisite concepts. These prerequisite concepts in turn depend on previously learned multiple discriminations, chains, and **Ss** $\rightarrow$ **R** connections. Essentially, any one of these prerequisites can be determined by empirical studies or by experience in teaching the subject (topic). When the hierarchy of the detailed structure of learning is not recognized, serious structural errors could result.

GLOSSARY

Glossary

Artificial Intelligence	Artificial intelligence is defined as the science of making machines do things that would require intelligence if done by men.
Chaining	Chaining involves combining or connecting two or more previously learned stimulus response relationships in sequence.
Concept learning	Learning a concept involves learning to respond to stimuli in terms of abstract properties. Concept learning helps the learner to identify a class of objects that differ from each. This identification is intuitive on the basis of an internalized representation.
Crowder Type Programs (multiple choice programs).	A Crowder type of programmed instruction uses the response as a test of whether the student has grasped an essential point of the passage and provides for frequent errors by explaining why an erroneous response is wrong.
Expert System	An expert system is a computing system which embodies organized knowledge concerning some specific areas of human expertise sufficient to perform duties in a skillful and cost effective manner.
Guthrie's Contingency Learning	Learning takes the form of an insight. An insight is a suddenly occurring reorganization of the field of experience, as when one has a new idea or discovers a solution to a problem.
Multiple Discrimination:	The individual learns to make a number of different identifying responses to as many different stimuli.
Pavlov's Classical Conditioning	The learning process includes a complex mixture of conditioned and unconditioned responses. When a new signal is associated with a set of events and repeated several times, the unconditioned responses can be learned. Salivation at the sight of food could be considered a natural or unconditioned response. Whereas, salivation to a buzzer sound is acquired as a conditioned response. Though common, most of the learning events are not based on conditioned responses.
Pavlov's Classical	Anticipatory responses such as the startled eye-blinking that may follow a threatening gesture are a part of a very

Conditioning (continue)	special kind of learning.
Principle learning	Principle learning is a chain of two or more concepts. Principle learning helps to control behavior in a manner suggested by the verbalized rule of the form.
Problem Solving	Learning to solve problems requires an internal event called thinking. Principles previously acquired are somehow combined to produce a new principle that is used to solve the problem.
Programmed Instruction	Programmed instruction is a learning experience in which a program takes the place of a tutor and leads the student through a set of pre-specified behaviors.
Signal Learning	Signal learning can be described as the individual learning to make a general, diffuse response to a signal. This is the classical conditioning response of Pavlov
Skinnerian Type Programs (constructed response programs)	A Skinnerian type of programmed instruction uses an ordered sequence of stimulus items, questions or statements.
Stimulus Response Learning	Acquires a precise voluntary response to a discriminated stimulus is called stimulus response learning.
Teaching Machines	Man made machines used to teach or tutor.
Thorndike's and Skinner's Reinforcement Theories	The associations resulting from the consequences of completed acts contribute to learning. When confronted with a novel situation, the motivated learner engages in various "tries" to attain satisfaction. The particular responses that lead to motive satisfaction become stronger in relation to others. The correct responses are progressively strengthened by being followed by motive satisfaction. This generalization was called "law of effect" by Thorndike. Skinner used the term "reinforcement" to identify the same events.
Verbal Association	Verbal association is the learning of chains that are verbal

VITA

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