THE EFFECTIVENESS OF A PERSONAL ROBOT IN PRESENTING A SOUND/FILMSTRIP AS MEASURED BY A ROBOTIC TECHNOLOGY ACHIEVEMENT TEST

DISSERTATION

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The problem of this study was to compare the effects of two methods of filmstrip presentation on student achievement. One method employed a personal robot to automatically advance a filmstrip projector in sequence with an audio cassette tape while the other method had a person manually advancing a filmstrip projector in sequence with an audio cassette tape.

The following research hypotheses were formulated for this study:

1. The experimental group will make a significant mean gain from the pretest to the posttest on a robotic technology achievement test.

2. The control group will make a significant mean gain from the pretest to the posttest on a robotic technology achievement test.

3. The experimental group will make a significantly higher mean posttest score than the control group on a robotic technology achievement test.

4. The experimental group will make a significantly higher mean delayed retest score than the control group on a robotic technology achievement test.

5. The experimental group will make significantly higher mean module scores on a robotic technology achievement test than the control group.

A Solomon Four-Group design was used to organize the volunteer subjects (N=84). Using the hypotheses as guidelines, the following were the findings of this study.

1. The pretested experimental and control subjects learned from the sound/filmstrip. The pretested experimental and control groups' mean posttest scores were significantly higher ($p < .05$) than their pretest mean scores.

2. The experimental groups did not achieve significantly higher mean scores ($p > .05$) on a posttest, delayed retest, or module mean tests than the control groups.

Using the findings of this study, the following conclusions were drawn.

1. Students learn from a sound/filmstrip on robotic technology whether it is presented by a human being or by a robot.

2. A robot is a viable alternative to the human teacher in situations where the student-teacher interaction is limited.

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CHAPTER I

INTRODUCTION

The word "robot" may conjure up in one's imagination a humanoid device similar to "Starwar's" C3PO. C3PO had many human characteristics and frailties so that when disasters befell it the audience had tremendous sympathy for its plight. A futuristic robot like C3PO exhibited a form of artificial intelligence that made it act very human. Today's intelligent robots are not quite as sophisticated, but still can perform many useful and complex tasks similar to those performed by human beings.

Historically, robots have been put to work in government agencies, industry, and education. The National Aeronautical Space Agency (NASA) for example uses a giant mechanical arm to help the astronauts remove and retrieve cargo from the bay area of the space shuttle. Industry uses robots to perform such boring tasks as welding, painting, and parts assembly. Educational institutions have used robots on a limited basis to teach such diverse subjects as mathematics, programming, and robotic technology. Many of the robots used for educational purposes are often referred to as "personal" robots.

Presently, robots are used in education primarily as a teaching aid. For example, a robot device called a "turtle" is used in conjunction with a microcomputer to teach grade school students the fundamentals of geometry and the LOGO programming language. The turtle moves in specific directions when certain LOGO commands are executed. The student learns geometrical principles and programming fundamentals because the student can observe the effects of the LOGO commands on the turtle (13, pp. 5-23).

Robots, in the more recent past, have not been used extensively for educational purposes primarily because most teachers and administrators have little knowledge about robot capabilities. In the last few years, however, companies have been producing relatively inexpensive, sophisticated robots well-suited for educational purposes. Heath Company, for instance, manufactures a robot called HERO that is used as an aid to teach the fundamentals of robot mechanics, microcomputer programming, and microcomputer interfacing. The HERO has an articulated arm, moves very accurately, has a programmable vocabulary, and can sense objects in its path and determine the distance to the objects with an ultrasonic ranging system (9).

Since robots are essentially microcomputers on wheels, they can perform many of the educational tasks that microcomputers now perform. Currently, microcomputers are used primarily to teach students individually by using such pedagogical designs as drill-and-practice, tutorials, and simulations (3, pp. 93-94). Robots could also perform individualized instruction using the same methods as computers, and may even be better at it, since many also have the ability to move and manipulate objects.

With the advent of microcomputer controlled robots, the educational possibilities for robots become virtually unlimited. Highly mobile robots are now being produced that are equipped with articulated arms, vision and voice recognition systems, and speech synthesizers (10). Robots with these capabilities should make excellent teaching machines.

A robot that can speak, either with a voice synthesizer or with a tape recorder, could lecture to a group of students. With the ability to move and manipulate objects, the robot (with the use of special control circuitry) could supplement lectures with filmstrips, videotapes, or overhead transparencies. Equipped with a voice recognition system, the robot could repeat information that is not clearly understood by the students; or, it may even be possible to program the robot to answer simple questions asked by the students.

Educational institutions will continue to use robots to teach math, programming, and robotic technology. Since the personal robot industry is expected to grow more than 100 per cent annually over the next six years, the educational applications for them should increase (12). As more teachers and administrators discover the capabilities of robots, the educational tasks that robots will perform will become more complex. A relatively complex educational task that robots can now perform is to give a sound/filmstrip presentation to a group of students much in the same way a teacher would present one.

Statement of the Problem

The problem of this study was to compare the effects of two methods of filmstrip presentation on student achievement. One method employed a personal robot to automatically advance a filmstrip projector in sequence with an audio cassette tape. The other method had a person manually advancing a filmstrip projector in sequence with an audio cassette tape.

Purposes of the Study

The purposes of this study were:

1. To determine what impact a robot controlled sound/filmstrip projection had on student achievement.

2. To determine what impact a human controlled sound/filmstrip projection had on student achievement.

3. To compare the effectiveness of two methods for presenting a sound/filmstrip. One method employed a personal robot to present a sound/filmstrip on robotic technology

while the other method for presenting a sound/filmstrip on robotic technology was done by a human.

To achieve the purposes, the student sample was divided into two control groups and two experimental groups. The effectiveness of the experimental variable was determined by administering a pretest to two of the groups and a posttest and delayed retest to all four groups.

Hypotheses

The following research hypotheses were formulated for this study:

1. The experimental group will make a significant mean gain from the pretest to the posttest on a robotic technology achievement test.

2. The control group will make a significant mean gain from the pretest to the posttest on a robotic technology achievement test.

3. The experimental group will make a significantly higher mean posttest score than the control group on a robotic technology achievement test.

4. The experimental group will make a significantly higher mean delayed retest score than the control group on a robotic technology achievement test.

5. The experimental group will make significantly higher mean module scores on a robotic technology achievement test than the control group.

Background and Significance of the Study

The concept of using robots to serve the wishes of mankind dates to the early Greeks when Homer described Hephaestus, the God of all mechanical arts. According to Homer, Hephaestus had two female golden statues that assisted and accompanied him wherever he went.

Robot design and construction progressed very little until the late Nineteenth Century when the Englishman George Moore designed and built the first "walking locomotive." The walking locomotive was built in the shape of a man and was driven by a small steam engine that could power the robot to a speed of nine miles per hour (9).

The modern industrial robot is a culmination of forty years of recent technological development. The historical sequence for the development of the industrial robot began in 1946 when George Devol invented a magnetic playback controller. At the same time Devol invented his playback recorder, the ENIAC computer was designed and built at the University of Pennsylvania. These two projects were significant because in 1954 Devol created the first programmable robot controlled by his magnetic playback recorder, while the ENIAC was the forerunner of all modern computers that are used in today's intelligent industrial robots (5, p. 46).

One of the major problems with the ENIAC computer was its use of vacuum tubes as logic switches. The use of vacuum tubes resulted in a computer of massive size with an incredible appetite for electricity. This problem was solved in 1948 when scientists at Bell Labs produced the world's first transistor. The transistor led to the development of the second generation of computers. These computers were generally smaller than the first and consumed much less electricity.

The second generation computers were still much too large and too expensive to use in most robots. The truly intelligent robot did not become feasible until the early 1970's when Intel Corporation invented the microprocessor which could be used as a central processing unit for a small computer (8, p. 3). This small computer is now referred to as a microcomputer and is used extensively as an intelligent controller for robots.

Robotic machines are used in industry in such diverse applications as spray painting, welding, machine loading-unloading, and parts assembly. Industrial robots that perform these types of jobs generally resemble the human arm. The robot can be stationary and have the work move by it; or, the robot can be mobile and move to the work. Mobile industrial robots are usually track mounted and have a limited area in which they can move or function.

Mobile industrial robots are generally very expensive and cost prohibitive for the average person. However, in the last five years a new, inexpensive mobile robot has become available to the general public. This new type of mobile robot is frequently referred to as a personal robot.

Personal robots were originally designed as an educational tool for hobbyists and educators. Educators use personal robots to teach robotic technology, geometrical concepts, and computer programming.

Teaching young children computer programming and geometrical concepts is a popular application for personal robots. In this application a small mobile robot called a turtle is connected to a microcomputer with a cable and is programmed by children to draw geometrical shapes on a piece of paper using a pen attached to the underside of the robot.

Stonier (16) describes a turtle that can be purchased for less than $250. This particular turtle is aesthetic in appearance, is battery powered and rechargeable, can be connected to any computer, and can move freely and accurately. According to Stonier, turtles are important because they generate excitement in children thus making them more interested in the learning process (16, pp. 52-53).

Microcomputers are an integral part of most turtles and personal robots. Since the microcomputer provides the "intelligence," the robot should be able to perform many of the teaching functions that microcomputers now perform.

Robots should even make better teaching machines because many are now being equipped with sensors that allow them to see, speak, and recognize voices.

The microcomputers used in the personal robot is similar to the ones used by many educational institutions. In the last decade there have been numerous studies on the effectiveness of microcomputers in education. Most research has shown that microcomputers are an efficient method for teaching various subjects. For example, Ploeger states that, "research has clearly demonstrated that instructional microcomputing can be a valuable educational tool" (14, p. 18). Ploeger goes on to say that microcomputers can improve learning skills as well as enhance affective measures such as motivation and self esteem; however, microcomputers are most effective as a supplement to other teaching methods.

Microcomputers are used primarily to teach students on an individualized basis rather than on a group basis. There have been, however, some attempts at using microcomputers to teach relatively large groups of students. Tamashiro suggests using a microcomputer as an electronic chalkboard much in the same way a normal chalkboard is presently used. The electronic chalkboard: 1) eliminates the problem of illegible teacher handwriting, 2) generates no chalkdust, and 3) presents the material in a neat and authoritative manner (17, pp. 3-4). With the acceptance by students that electronic media is authoritative and reliable, teachers find that students tend to be more attentive and motivated.

An interesting group teaching application for the microcomputer is its use as an intelligent slide projector controller. Barker (1) describes a system for using a microcomputer to control a slide projector in such a manner that slides can be shown in a random fashion. The order of the slide sequence is determined by a microcomputer program. The major advantage of using the microcomputer controlled slide projector is that by changing the program the slide sequence can be altered. This is especially useful in computer assisted instruction (CAI) where slides would have to be changed according to the response given by the student. According to Barker, slides are effective means for transmitting information because of the large amount of highly resolved detail that can be contained in a picture (1, p. 2).

Various studies have been done on the effectiveness of slides, overhead transparencies, and filmstrips. Most of the comparative studies between different types of still media and traditional teaching methods were completed by the early seventies. Doctoral Research In Educational Media 1969-1972 listed twenty still media studies of which sixteen were experimental in nature (11, pp. 69-71). Most of the experimental studies compared some form of still media by itself, or as a supplement to traditional teaching methods, to other types of media (textbooks, audio-tapes, etc.), or traditional lecture-laboratory methods. Approximately 30 per cent of the studies resulted in a significant difference between methods with the remaining studies showing no significance. Most experiments showing no significant difference had generally higher mean scores on the experimental method (media) than on traditional methods.

A typical study on the effectiveness of media was performed by Dwyer. Dwyer (6) conducted an experiment in which oral presentations alone were compared to oral presentations complemented with selected types of visual media. The topic that was selected for the experiment was the human heart. The oral presentation was tape-recorded and presented to the subjects by the means of television. Five separate sets of slides were used to complement the television instruction. The information presented on each set of slides was essentially the same, with the differences among slides being the amount of realistic detail. Subjects were randomly assigned to five groups with one group being the control (oral presentation only) while the other four groups were experimental (oral presentation complemented with visuals). Five criterion measures were used to determine the effectiveness of the experiment. These measures were: 1) drawing, 2) identification, 3) terminology, 4) comprehension, and 5) total comprehension.

Significant differences were found in four out of the five criterion tests when measured against the control with the highest positive significance occurring on the drawing measure.

Dwyer concluded that visuals were effective when learning objectives were similar to those measured by a drawing test but may be unnecessary when using the other criterion. Dwyer goes on to say that visuals should be used when the student is required to draw together concepts in forming generalizations and/or comparisons or to conceptualize precisely specific abstract concepts and relationships in order to comprehend some manipulative test or process. (6, p. 10).

Significance of study.--In today's educational environment there are many examples of technological devices teaching technology. A prime example is in the use of microcomputers to teach everything from beginning computer programming to advanced electronic theory. The microcomputer has been primarily limited to teaching students on an individual basis and has not been used extensively on a group basis.

Personal robots have become a viable educational tool with the advances made in microcomputer technology, sensors, vision systems, speech synthesis, and voice recognition. The personal robot that has the ability to move and speak could be programmed to control and narrate a filmstrip presentation to a group much in the same way a teacher does.

This study was significant in that it:

1. Determined whether a personal robot would be an effective educational tool for presenting a filmstrip to a group of subjects. This information would be useful to vocational-technical schools, community colleges, and four-year institutions that have personal robots and are trying to find some useful application for them other than teaching robotic technology. Teachers who have access to personal robots could use them to show sound/filmstrips and other types of instructional media. This would allow the teacher more time to work with slower students who might need more individual attention.

2. Provided significant information for personal robot manufacturers to help in the promotion and sales of their robots.

3. Enabled companies that produce filmstrips and other types of media to use this information for promoting the sales of their products at educational conventions and other media displays. (See Appendix A.)

Definition of Terms

The following terms are defined as they relate to this study:

Achievement Test is a test that measures the current status of individuals with respect to proficiency in given areas of knowledge or skill (7, p. 124).

Filmstrip is a series of slides which exist on one strip of film instead of being cut into individual slides. Each frame is usually half the size of a normal slide.

Filmstrip Projector is a device used to project the filmstrip image onto a screen. The filmstrip projector has a built-in cassette player and can be advanced manually using an external switch. A typical filmstrip projector is the Singer Educator.

Filmstrip Series is a group of filmstrips dealing with a particular subject. Each individual filmstrip is called a module. Each module has an accompanying audio cassette tape that contains the narrative and the projector advance tone. A 50 Hz silent tone is used for automatic advance while a 1000 Hz tone is used for manual advance.

Industrial Robot is a reprogrammable, multi-functional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks (15).

Instructional Media are different types of audio-visual technologies such as filmstrips, slide-tapes, overhead transparencies, videotapes, etc.

Microcomputer is a small computer that is used to control the movements of a personal robot. The microcomputer also controls the operation of the the robot's onboard cassette tape player.

Microprocessor is the central processing unit for a microcomputer. It performs all control, arithmetic, and logic functions.

Personal Robot is a microcomputer controlled, mobile platform that has the ability to move accurately and speak using a cassette recorder.

Robotic Technology is the study of industrial robots and their applications in industry.

Delimitation

For the purposes of this study the following delimitation was imposed.

1. The experiment included only those students taking courses in the Division of Industry at Southeastern Oklahoma State University in Durant, Oklahoma.

Assumptions

The design of this study was based upon these assumptions.

1. It was assumed that neither the control groups nor the experimental groups was affected by any uncontrolled variables.

2. It was assumed that all subjects answered all test instruments to their best abilities.

Procedures for Collection of Data

Permission was obtained from the Chairman of the Division of Industry to solicit volunteers from the departments of Electronic Technology, Drafting and Design Technology, Metals Technology, and Industrial Technology. (See Appendix F.) The subjects were randomly assigned to four groups of which two were pretested using an instrument developed by the researcher. The completed pretest instrument was graded using a computer with the results being placed in an electronic spreadsheet for future analysis. Approximately two weeks after administering the pretest the experiment was conducted.

The experiment was conducted for a period of six days beginning on a Monday at 8:00 AM. Each of the four groups was given a treatment followed immediately by a module achievement test. The module scores were graded using a computer with the results being placed into an electronic spreadsheet. The spreadsheet sum function was used to obtain a final posttest score for each participant. The posttest scores were used to determine the effectiveness of the experimental variable.

Approximately two weeks after the completion of the experiment, delayed retests were administered to all groups. The delayed retest was a concatenation of all the individual module tests. The retest was graded using a computer with the results being placed into an electronic spreadsheet. The scores obtained from the retest were used to determine the effectiveness of the treatment over time.

To ensure the integrity of the data obtained from the experiment, all subject data were scrutinized for missing scores. If a subject was missing a score, or a number of scores, the data for that subject were omitted from the study.

Instrument.--The robot showed a filmstrip series on robotic technology produced by the Library Filmstrip Center located in Bloomington, Illinois. Upon contacting the Library Filmstrip Center it was discovered that no test instruments had been developed for their filmstrip series entitled Robotics.

The filmstrip series consisted of six separate modules each dealing with a topic related to robotic technology. The researcher developed a multiple choice achievement test for each module. For validation and reliability purposes the module tests were assembled into a pool of 159 test items.

Test content validation was accomplished by having a panel of experts view the filmstrip series. After viewing a module they evaluated each question on the module test by marking a five point scale that ranged from 1 (poor) to 5 (excellent). From the responses of the panel members, means were calculated for each test item. The sixteen highest rated test items for each module were retained for the final test. The reliability was then determined by the split-half method.

The test was administered to 104 students and graded on a computer using odd and even keys. The use of odd and even keys resulted in each student having two scores, one for the even items and one for the odd items. A Pearson product-moment correlation was conducted using the odd scores as one variable and the even scores as the other. The Spearman-Brown prophecy formula was then applied to the results to compute the final reliability (7, p. 120).

Population.--The population for this study consisted of students taking classes in the Division of Industry. The Division of Industry is part of the School of Business and Industry and consists of four major departments: 1) Electronic Technology, 2) Metals Technology, 3) Drafting and Design Technology, and 4) Industrial Technology. The Division of Industry has an average population of approximately 600 students for the fall semester and 500 students for the spring semester.

Selection of the Sample.--The sample for this study was obtained through the solicitation of volunteers from the Division of Industry. Approximately four weeks prior to the beginning of the experiment, an advertisement for volunteers was placed in conspicuous locations throughout the Division. Approximately one week after the posting of the advertisements the researcher talked to classes within the Division on the importance of the study and the need for volunteers. Solicitation of subjects continued until a maximum of 104 students volunteered. The subjects were randomly assigned to four groups of equal size using a microcomputer program written by the researcher.

Research Design.--A Solomon Four-Group design was used for this experiment (4, pp. 24-25). (See Table I.) The

TABLE I

SOLOMON FOUR-GROUP DESIGN

Group I	R	O	X	O
Group II	R	O		O
Group III	R		X	O
Group IV	R			O

Key: R= random assignment
X= experimental treatment
O= observation, either pretest or posttest

Solomon Four-Group design was selected because: 1) it assessed the effects of the experimental treatment relative to the control treatment, 2) it assessed the effect of a pretest, 3) it assessed the interaction between pretest and treatment conditions (2, p. 691), 4) this design has the greatest protection against the major sources of internal and external invalidity.

The dependent variable for this design was the tests given to the experimental subjects immediately following their treatments. The independent variable was a robot controlled sound/filmstrip presentation.

Groups I and II were pretested while groups III and IV were not pretested. Approximately two weeks after the initial pretesting the experiment was conducted in room 303 at Southeastern Oklahoma State University's Engineering Technology Building.

The experimental groups (I and III) and the control groups (II and IV) were shown six filmstrips that lasted between eleven and fifteen minutes. The experiment began on a Monday at 8:00 AM with Group I being shown module one by the robot. Immediately following the filmstrip, a ten minute posttest was administered to all participants. The total time required for the first session was forty minutes which allowed approximately twenty minutes to prepare for Group II.

At 9:00 AM Group II was admitted to the classroom and shown module one by the classroom monitor. Upon completion of the filmstrip, a ten minute posttest was administered to the subjects. When all subjects had completed the test instrument, they were allowed to leave the classroom. The total time required for Group II was thirty-five minutes.

This process continued until all groups received a treatment and a posttest. The total time required per day to complete both treatments and testing for all four groups was four hours. Table II shows the schedule that was followed for the six day period.

TABLE II

GROUP SCHEDULE

	DAY					
BEGIN TIME	1	2	3	4	5	6
8:00	G1	G2	G3	G4	G1	G2
9:00	G2	G3	G4	G1	G2	G3
10:00	G3	G4	G1	G2	G3	G4
11:00	G4	G1	G2	G3	G4	G1

Filmstrip series.-- The series of filmstrips that was shown to the subjects was entitled Robotics and was published by the Library Filmstrip Center located in Bloomington, Illinois. Permission was obtained from the Library Filmstrip Center to use these filmstrips for this experiment. (See Appendix A.) Permission was also granted to copy all of the audio cassettes for archival purposes. The copied cassette tapes had information placed on them before and after the robotics presentation so that the robot would give a more coherent and realistic presentation.

The filmstrips consisted of six modules on industrial robotic technology. Each filmstrip had an accompanying audio cassette with the sound for each filmstrip recorded on both sides. One side was used to advance the filmstrip automatically while the other side contained an audio tone that was used to advance the filmstrip manually. For this study the audio tone version was used with each filmstrip. Table III lists the titles of each filmstrip and the time in minutes and seconds required to show each one.

TABLE III

FILMSTRIP MODULE TITLES AND TIME FOR EACH

Module	Title	Time
1	Robots In Industry	15:38
2	Robot Sub-Systems	11:27
3	Operating Parameters of Robots	13:39
4	Applications of Robot Technology	11:34
5	Implementation of Robots	13:49
6	Human Factors in Robotics	12:08

The experimental groups were shown the filmstrips by a personal robot that controlled a Singer Educator filmstrip projector using the projector's manual advance. The robot carried a cassette recorder that played the tapes which accompanied each filmstrip. The robot advanced each frame of the filmstrip when an audio tone was produced by the tape recording.

Besides having the robotic technology information on the tapes, the cassette tapes had a recording at the beginning that greeted the students and previewed the module as well as a recording at the end that explained the directions for taking the test. The information on the cassette tapes concerning robotic technology was not altered in any manner.

The control groups were shown the same robotics filmstrip as the experimental groups. A Singer Educator filmstrip projector was used to show the filmstrips while a separate tape recorder was used to play the appropriate cassette tapes. The audio tone side of the cassette tape was utilized so that the filmstrip could be advanced manually by a classroom monitor.

Approximately two weeks after the completion of the experiment, a retest was administered to all participants. The scores obtained from the retest was inserted into an electronic spreadsheet and analyzed for significance between the experimental and control groups.

Pilot test.--A pilot test was conducted prior to the actual experiment. The pilot test: 1) determined the electrical and mechanical characteristics of the robot, 2) determined the programming required to make the robot perform its assigned tasks, 3) determined an initial reaction of subjects to the robot and filmstrip, and 4) elicited suggestions from colleagues and students on methods to improve the robot's performance. The pilot test was conducted using a posttest, control-group design (4, pp. 15-26). (See Table IV.)

TABLE IV

POSTTEST-ONLY CONTROL GROUP DESIGN

Experimental Group	R	X	O
Control Group	R		O

Two classes were selected from the Electronic Technology Department and randomly assigned to experimental and control groups. The experimental and control groups were shown the filmstrip, "Robots In Industry." Posttests were administered to both groups at the end of the treatments. The posttests were tested for significance using one-way analysis of variance.

After the completion of the posttest by the experimental and control groups, an informal session was conducted so that suggestions could be offered by the subjects on ways to improve the presentations. Faculty members of the

Division of Industry sat in on the sessions and also offered suggestions on improving the presentations.

Robot.--The robot used for this experiment was designed and built by the researcher at Southeastern Oklahoma State University. (See Appendix B for a complete description.) The robot consisted of a microcomputer controlled mobile platform with a plastic body mounted directly to the platform. The microcomputer controlled drive system employed by the robot allowed it to accurately transverse long distances.

Procedures for Analysis of Data

After all data had been collected they were analyzed according to the statistical procedures detailed in *Experimental and Quasi-Experimental Designs* (4, pp. 24-25). Descriptive statistics were calculated for all groups and placed into tables. The statistics were calculated on an IBM PC microcomputer using a commercially available statistical package. For testing purposes, each hypothesis was restated in the null form and tested at the .05 level of significance.

Testing of Hypotheses.--A t-test for correlated means was used to test Hypotheses 1 and 2 while two-way analysis of variance was used to test Hypotheses 3 through 5 (2, pp.

694-695). The analysis was performed using a commercially available microcomputer statistical package.

Reporting the Data.--After all data had been collected, they were entered into tables for comparison simplification. Histograms and line graphs were used to display descriptive statistics and information relating to Hypothesis 5.

Organization for the Remainder of the Study

A review of the related literature is presented in Chapter II. Chapter III contains the methodology, while Chapter IV contains the analysis of the data. The summary, conclusions, and recommendations are presented in Chapter V.

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CHAPTER II

REVIEW OF THE LITERATURE

The purpose of this chapter is to review the literature related to robots and their applications in education. This chapter is organized into: 1) literature related to industrial robots, 2) literature related to personal robots, 3) literature related to robots in education, 4) literature related to instructional media, and 5) literature related to pretest effects.

Literature Related to Industrial Robots

History.--The word robot means "menial labor" and was coined by Czech playwright Karl Capek for the 1921 play R.U.R. (Rossum's Universal Robot) (22, p. 8). Automated mechanical devices have been in existence since the beginning of the Industrial Revolution; however, the first programmable controller was invented and patented in 1946 by George Devol. In 1961 Joseph Engelberger bought the patent rights from George Devol and started Unimation, the first industrial robot manufacturer. Unimation was bought out by Westinghouse in 1982 (11, p. 45).

With the advent of the microprocessor, robots have become "intelligent machines." In 1976 Cincinnati Milacron produced the first microcomputer controlled robot and in

1977 the ASEA corporation produced the first microprocessor-controlled electronic activated robot. Today the six leading industrial robot manufacturers in the United States are Unimation, Cincinnati Milacron, DeVillbiss, Prab, ASEA, and Copperweld (35, p. 7).

Robot Technology.--Industrial robots are being put to work in factories throughout the world. The tasks that these robots perform range from simple pick-and-place movements to sophisticated welding and painting operations. Industrial robots can perform complex operations because many of them are built to mimic the movements of the human arm. To achieve the flexibility of the human arm, the industrial robot or manipulator is constructed with a series of flexible joints called axes or degrees of freedom. The more axes a robot has the more complex tasks the robot can perform. Robots typically have from three to five degrees of freedom (19, pp. 4-11). (See Figure 1.)

Attached to the end of the manipulator is the gripper, end effector, or end of arm tooling. The gripper can be a general purpose handlike device or it can be a tool or fixture designed for a specific industrial operation.

The axes of the robot are driven by hydraulic, pneumatic, or electrical actuators. Hydraulic actuators are used where strength is required while pneumatic actuators are used primarily in low cost pick-and-place robots.

Electric actuators or motors are used where a high degree of position accuracy is required.

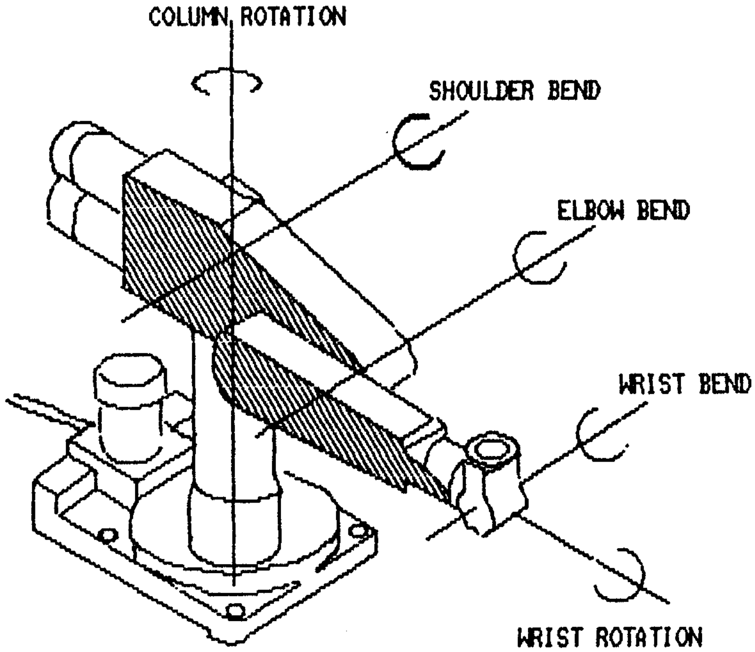

Fig. 1--Manipulator

The robot's movements are activated by a controller which is a microcomputer for most intelligent robots. The microcomputer allows the robot to be programmed or reprogrammed for specific tasks and also processes information from such devices as video cameras, tactile sensors, and ultrasonic transducers.

Robot Applications.--Robots are generally classified into three major categories: 1) low technology or pick-and-place robots, 2) medium technology robots, and 3) high technology robots. The tasks that a robot can perform are primarily determined by its classification.

Low technology robots are used for relatively simple tasks such as material handling, press operations, injection molding, and machine loading and unloading. The low technology robot accounts for approximately 35 per cent of all robots in use in the United States today (19, p. 16). Practically all low technology robots are open loop devices, that is, they have no feedback from the axes to indicate position. Open loop robots are called non-servo robots.

Low technology robots are generally limited in movement (two to four degrees of freedom). The axes use either hydraulic or pneumatic actuators and are driven by electronic or mechanical controllers. The manipulator movement is generally limited by switches and/or mechanical stops.

Medium technology robots are used in many of the same applications as low technology robots. However, the medium technology robot has more degrees of freedom (usually four to six) and thus allows it to serve more than one machine at a time (19, p. 36). The payload for medium technology robots tends to be greater than low technology robots which makes them more useful in loading and unloading heavy parts from machines and furnaces.

High technology robots have five or more degrees of freedom and a microprocessor based controller. This combination allows the high technology robot to perform relatively complicated industrial tasks such as welding, spray painting, and component assembly.

High technology robots employ hydraulic or electric motors to actuate the various axes. The motors have electronic sensing devices attached to them so that the controller can tell where the axis is at any given time. Robots that employ this technique are called servo controlled robots.

Servo controlled robots have the ability to move precisely from one point to another or they can move continuously along a given path. Robots that move from one point to another are called point-to-point robots while robots that can move continuously along a given path are called continuous path robots. Point-to-point robots are used extensively for assembly operations while continuous path robots are used for arc welding and spray painting.

Growth in Robot Use.--Currently there are 50 robot manufacturers in the United States and approximately 400 worldwide. In 1980 the United State had approximately 4000 robots in use. With an annual growth rate for the robotics industry of almost 30 per cent per year, the number of robots in use by 1990 will be more than 100,000 (34).

Figure 2 shows the projected applications of robots as a percentage of total robot population between 1980 and 1990 (34, p. 3).

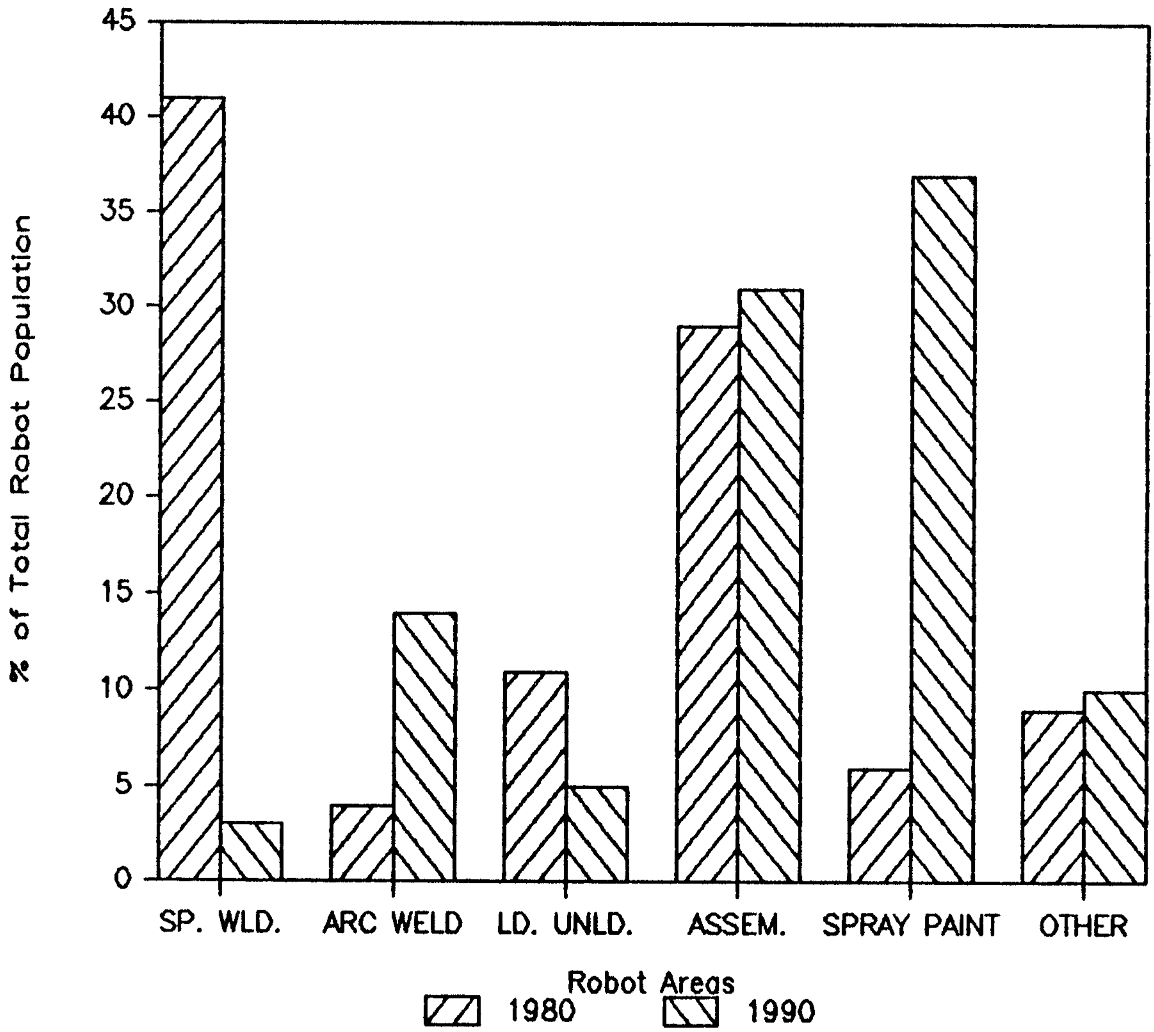

Fig 2.--Robot applications areas as a percentage of total robot population

Literature Related to Personal Robots

Industrial robot manufacturers have considered personal robots a domain of the hobbyist and experimenter. Industrial robots, until recently, have been nothing more than a deaf, dumb, and blind imitation of the human arm and hand. Recently more industrial robots have been acquiring sensory perception, advanced language, and mobility just as the personal robot has. The technologies for industrial and personal robots appear to be converging so that by the end of this decade, robots will no longer be divided into industrial robots and personal robots but will be just robots "under the skin" (15, p. 4). Personal robots are generally divided into three major categories: 1) turtles, 2) arms, and 3) mobile robots (9, p. 60).

Turtles.--Turtles are small, circular, wheeled robots that are connected to a microcomputer with a cable. Usually the turtle has a pen attached to its underside so that it can draw pictures on a flat surface. Turtles were originally used to teach geometry and the programming language LOGO to grade school students. However, with the introduction of new microcomputers, the mechanical turtle has been replaced in many instances with a graphics turtle.

Presently there are more than six companies producing turtles for prices that range from a few hundred dollars to more than a thousand. Some of the more sophisticated ones have onboard microcomputers and have no connections to a stationary microcomputer (9, p. 62).

Arms.--Arms are small imitations of industrial manipulators. They are generally used in classrooms to teach the fundamentals of robot mechanics, electronics, and programming. Cost and safety are the two primary reasons for using arm-type personal robots.

Mobile robots.--Mobile robots are usually the ones most people think of as being robots because many are anthropomorphic in nature. Most mobile robots have an onboard microcomputer that controls the movement of the robot. Many commercially available mobile robots have speech capabilities, voice recognition, ultrasonic ranging systems, light detection capabilities, and vision systems.

Mobile robots are used primarily by technical hobbyists and educators. Like the robot arm, the mobile robot is used by educators to teach the fundamentals of robotic technology. Technical hobbyists use them primarily for experimentation and educational purposes.

Mobile robots are the largest selling group of all the personal robots. In 1983 one company sold more than 8000 robots ranging in price from $1250 to $2500. Most of these robots were sold to technical hobbyists and educational institutions (9, p. 62).

Heath/Zenith Corporation has recently developed a new mobile robot called the HERO 2000. The HERO 2000 has a master microprocessor that is used to control the operation of eleven slave microprocessors. This gives the robot multitasking abilities that allow it to do more than one operation at a time. For example, the robot can control the movement of its arm while at the same time it generates speech from its on-board speech synthesizer (7).

Heath/Zenith has primarily designed the robot as an educational tool to teach design and control of mechanical elements and as a testbed for professionals in robotics and automation. Three courses are presently available that teach automation, programming, and computer interfacing (7, p. 49).

Literature Related to Robots in Education

Robot literacy is a natural extension of computer literacy since robots are essentially microcomputers on wheels. Robots have the ability to teach students programming skills, mathematical insights, and manual dexterity skills. Robots are machines that have infinite patience and can perform repetitious learning tasks which many students need. Since the robot is a machine, the robot should be viewed by the student as a teacher that corrects but does not challenge self-image (18, pp. 221-223).

Robots are being used in education mainly as a technical teaching tool. They are used in simulations and special education, and to assist in the teaching of such diverse subjects as computer programming, mathematics, and robotic technology.

Programming and mathematics.--Papert in the late sixties and early seventies developed a computer language called LOGO that was initially designed to teach the fundamentals of geometry and computer programming to young children (26, pp. 3-12). The main device for teaching geometrical shapes was the turtle. The turtle, under computer control, would draw geometrical shapes on a piece of paper. The students would have to write the programs in LOGO to draw the desired patterns. Papert declared that the students would have a better understanding of geometry and programming because children "learn by doing, and by thinking about what they do" (28, p. 4). Papert states in an essay on computer applications in education:

> ....I believe with Dewey, Montessori and Piaget that children learn by doing and by thinking about what they do. And so the fundamental ingredients of educational innovation must be better things to do and better ways to think about oneself doing these things (29, p. 1).

Turtles used with LOGO can be mechanical or graphic. Either type of computer controlled turtle is a useful device for teaching geometrical principles.

The mechanical turtle moves when LOGO commands are issued by the student to the computer. The command FORWARD 1, for instance, causes the turtle to move forward a small distance while FORWARD 10 causes the turtle to move a larger distance. Other commands cause the robot to turn, stop, and extend and retract a pen. The graphics turtle also moves when LOGO commands are issued by the student; however, the turtle moves on the computer screen. Both turtles have their strong points: the mechanical turtle can draw pictures and be used as a bulldozer while the graphics turtle can draw bright colored lines faster than the human eye can follow. Neither has an advantage over the other, but each conveys the mathematical concept that two physically different devices can be mathematically the same or iso-morphic (27, p. 56).

The teaching effectiveness of robots has not been scientifically explored by educational researchers. The primary reason for this is the deficiency of expertise among educators on the availability and capabilities of robots. However, in the last four years there has been some suggestions and pilot studies on the educational applications of robots.

Delgado (10) conducted a pilot study in which she used a mobile robot to assist in the remediation of students who lacked skills in language, reading, and mathematics. The students ranged in age from seven to thirteen and were from different ethnic and economic backgrounds.

Delgado observed that the students gained many insights in mathematics that were previously unknown to them. They learned geometrical shapes and spatial relationships, the meaning of degrees in a circle, and the meaning of decimal points. Also they learned the meaning of certain programming techniques such as looping and conditional statements.

The robot, according to Delgado, can be a special tool in education because it is a concrete, three dimensional device, with which the students can interact and observe. Students can program the robot and observe instantly the effects of their programs on the movement of the robot. Students gain control over a tangible object which can assist in their learning strategies and work patterns.

The robot's educational possibilities have been barely recognized. Delgado stated that personal robots could teach certain things better than the way they are presently being taught and may also be able to teach things that cannot now be taught.

In an article by Watt (36), she described a project where she brought some personal robots to an elementary school. Watt let the students program two different robots, one mobile and one turtle. Watt observed that the students became excited and worked diligently to program the robots.

Watt stated that robots take children "into an interactive, problem solving environment" and that robots can be used by a group or an individual (36, p. 75). Unlike microcomputers, the robot is a large enough object that everyone can see so that group lessons can be taught on problem solving strategies, program writing, and debugging skills.

Simulations.--Behnke and others (2) described a robot that will be used to simulate a life-sized video image of a human communicator. The robot will be designed to ask questions, make remarks, or react in such a way as to convey the idea that one is actually talking to a live interviewer. The actual picture will be generated by quickly showing previously recorded images in quick succession so as to give the appearance of a person carrying on a normal conversation.

Behnke asserted that life-sized images "preserve the sense of immediacy and reality" (2, p. 7). He contended that this is true because many televised news programs use life-sized images when the host is interviewing individuals thousands of miles away.

The use of the video robot would have advantages over traditional methods of instruction. According to Behnke the video robot would: 1) compensate for individual learning styles, 2) provide immediate feedback and engage the learner in an active way, 3) compare behaviors or performances so that appropriate evaluations may be assigned, 4) promote learner enthusiasm, 5) increase instructional productivity, and 6) force the instructor to prepare more thoroughly.

Behnke initially plans to use the video robot as a job interviewer. The applicant will come into a room and sit at a table that has a large video screen in front of it. The table will have a computer terminal on it that would allow the interviewee to communicate with the robot. The robot will begin the interview with some opening comments followed by some questions relating to the applicant's interest, education, and experience.

The hardware that will be initially used to generate the video robot will be a computer controlled videodisc player. The computer will be programmed to respond to as many possible combinations of questions that the interviewee may have. Any questions that are not recognized by the computer will be answered with general responses such as "I'm not sure I understand, could you elaborate" (2, p. 9).

Behnke suggested that the video robot could be improved by the use of split-screen video recordings of the robot and subject. The post-analysis of the interview session could be used to improve the performance of the robot and interviewee. Another improvement that would increase the realism of the video robot is to use a voice recognition system in conjunction with artificial intelligence. This would allow the interviewee to interact with the robot in a more personal manner. Behnke and his associates concluded "that both research and instruction are facilitated by the development of video robotics and that individuals exposed to it are fascinated by its present capabilities and future potential" (2, p. 10).

The concept of the video robot could be carried one step further to include mechanical, humanoid, robots. Humanoid robots would perform the same type of interviewing functions as the video robot but would also have the advantage of being mobile. Mobility would include arm movements as well as the ability to stand-up and sit-down. With this ability, the humanoid robot would add a three-dimensional realism that the video robot could not achieve.

Special education.--Personal robots have particular relevance in special education. Kimbler (20) described appropriate applications for personal robots in this area. Kimbler divided the functions of robots into two distinct categories. First, the robot could be an auxiliary to education. The robot could provide a unique student interaction, it could aid in student motivation, and act as an extension of the teacher. According to Kimbler, the applications of robots are limited to the creativity of the teachers and professionals that use them (20, p. 68).

The robot, secondly, could be used as a physical extension of an individual. This function is extremely important in special education because many students are physically handicapped and could use the robot to meet their needs, goals, and aspirations. The type of robot that would be required for this application would be determined primarily by the student's physical abilities. Presently there are no robots available that are sophisticated enough to meet the demands required by all handicapped individuals.

The specific uses of robots in education can be categorized as either teacher-initiated or student-initiated. Teacher-initiated uses of robots closely follow those applications of traditional methods. Robots involve students because of their novelty and unusual appearance. They may be used to illustrate and reinforce material much in the same way that traditional material is presently used. Robot use in these applications applies equally to conventional students and special education students.

Demonstration is an additional application for the robot in education. The robot could be used to present its own qualities and characteristics, and to present modern technology in the classroom (20, p. 69). Robots for this application would apply to all students but would have particular importance for handicapped students.

Kimbler indicated that the student-initiated uses of robots are especially important to handicapped students because of the potential impact that robots can have on the quality of life. The robot allows the handicapped student to have control over his environment thus giving the student an intangible feeling taken for granted by most people.

The robot is particularly important to individuals who have limited mobility, dexterity, and interaction with their environment. The robot would be especially useful to the orthopedically handicapped and those individuals with visual or aural impairments. For orthopedically handicapped people the mobile robot could act as an extension of arms, hands, or legs while the robot with sensors could be used to provide information to the visually or aurally impaired.

Presently there are no robots that have the capabilities required by most handicapped individuals. Research is now being done in areas that will substantially increase the mobility, sensory capabilities, and conversational input-output of robots. Integrating these facilities will be required if the robot is to be a useful device to the handicapped person.

Kimbler concluded that research will be done in robotic technology so that the robot will become a true extension of the individual. The primary limiting factor to robot development will be financial if robots are exclusively developed for the handicapped. However, if the robots are developed for the general population as well as for the handicapped, the robot may become a viable educational tool for all people (20, p. 76).

Robotic technology.--Personal robots are used extensively to teach robot mechanics, electronics, programming, and applications. Mobile robots and arms are used for these purposes.

Adams (1) surveyed the _1983 North American Directory of Robotics Education and Training Institutions_ and discovered that 27 universities, colleges, and community colleges offered full degree programs in robotics education while 343 institutions offered courses related to robotic technology.

Robotic technology is primarily taught at the engineering level and community college level. Engineering schools are primarily concerned with teaching engineers robot theory, design, and applications in an industrial environment while the community colleges are concerned with teaching technicians robot maintenance and programming.

Newton (24, p. 4) reported that robotics is not a field unto itself but a combination of technical disciplines. The technologies which he suggested should be part of a robotic curriculum are:

1. Electronics (digital)
2. Electricity
3. Hydraulics/Pneumatics
4. Computer Languages
   - Machine Language
   - Assembler
   - Basic
   - High level user friendly languages
   - Manufacturing Processes

Robotic curricula are being implemented in vocational-technical schools, community colleges, and colleges and universities (3, pp. 122-123). A typical secondary vocational-technical curriculum would include such topics as:

1. Definition of the term robot.
2. Basic components of an industrial robot.
3. Purposes of robots in Industrial Applications.
4. Basic considerations in implementing robots for specific applications.
5. Types of robots.
6. Robot motion.
7. Summary of component functions.
8. Methods of programming.
9. The robot in the workplace.
10. Required robot characteristics.
11. Advantages of robot applications.
12. Disadvantages of robot applications.
13. Applications of robots in industry.

Literature Related to Instructional Media Studies

Instructional media is an important part of systematic teaching. A general definition of a medium is any person, material or event that allows a student to acquire knowledge, skills, and attitudes. A teacher, textbook, or school environment could be media according to this definition (16, p. 241). Technically however, media is the "graphic, photographic, electronic, or mechanical means for arresting, processing, and reconstituting visual or verbal information" (14, p. 164).

Media technology is generally divided into two major categories, material and equipment. Material is the information and concepts that are stored on a medium while the projector required to exhibit it is considered to be the equipment. Today the material is often referred to as software and the equipment hardware. Hardware would include such equipment as filmstrips, projectors, computer disks, and microcomputers.

The properties of media can be categorized into three major groups: 1) the fixative property, 2) the manipulative property, and 3) the distributive property. The fixative property "permits the capture, preservation, and reconstitution of an object or event" (16, p. 244). Computer disks, photographic film, and magnetic media such as audio tapes are used to fix objects and events. The manipulative property of media allows the transmutation of an event or object. An example would be the manipulation of a film to slow-down action so that one could observe what is actually taking place. The distributive property allows the conveyance of media through space. This characteristic allows many students to view educational material simultaneously (16).

There are essentially six types of media available to the educator. These media are: 1) still pictures, 2) audio recordings, 3) motion pictures, 4) television, 5) real things, simulations, and models, and 6) programmed and computer assisted instruction (CAI) (16, pp. 248-249).

Still pictures are frequently used by educators to present information to a group of students in an effective manner. One common type of still picture presentation is the sound/filmstrip. Roach (33, p. 11) states that a "filmstrip with verbal amplification or audio-explanation will reach an optimum number of students in the classroom."

A filmstrip has a number of advantages over the traditional lecture method. The filmstrip is relatively inexpensive, it can emphasize areas of specific interest to the teacher, it can display information immediately (no waiting while the teacher draws on the chalkboard), frames can be frozen or repeated for more detailed explanations, and filmstrip projectors are easy to operate and relatively jamproof (33, pp. 11-12).

An instructional media technique that has become increasingly popular in the last ten years is computer assisted instruction (CAI). CAI has become one of the most widespread instructional technologies because of the availability of microcomputers and the ability of CAI to meet the individual needs of the student.

CAI has not been used to teach groups of students mainly because of the limited size of computer screens. A microcomputer controlled robot on the other hand, could easily control a mass media device such as a filmstrip projector and teach relatively large groups of students. The review of the literature for this section will be primarily limited to comparison studies on: 1) instructional media (filmstrips, slide-tapes, films, etc.), and 2) CAI.

Instructional Media Studies.--Rankowski and Galey (32) performed an experiment to determine the effectiveness of instructional media in the teaching of descriptive geometry. Students were randomly assigned to eleven geometry classes. Five classes were used as a control group while the remaining six were used as the experimental group. The experimental treatment consisted of a lecture and a multimedia presentation. The multimedia used for the experimental group was slide-tape and videotape. The control group was taught descriptive geometry using a conventional lecture method supplemented by chalkboard illustrations.

The experimenter examined four variables: 1) spatial relation visualization, 2) achievement in descriptive geometry, 3) descriptive geometry problem solving, and 4) attitude toward descriptive geometry. A multivariate t-test was used to determine the significance among the different variables. Three of the four variables were significant at the .05 level while two were significant at the .01 level. The only variable that was not significant was spatial relation visualization. Rankowski and Galey concluded that the use of videotapes and slide-tapes in group lectures significantly increased student achievement and reduced the variance among students.

Biekert (4) performed a study that compared the relative effectiveness of two methods for teaching numerical control manual programming. One method employed lectures with visual media (experimental treatment) while the other method employed a lecture/demonstration/hands-on equipment approach. The visual media used were: 1) overhead transparencies, 2) video-tape recordings, and 3) sound films. The experimental group consisted of 26 students while the control group had 21 students.

Biekert employed the t-test to determine the effectiveness of the two methods. He found that there were no significant differences between the visual method and hands-on method at the .05 level. This conclusion is important because the cost of numerically controlled machines is quite high. The use of lectures supplemented with visual aids to teach numerical control programming would be an inexpensive alternative to the use of numerically controlled machines.

Brum (6) studied the effects of audio-visual supported instruction on student grade point average. An economics course was divided into experimental and control groups. The experimental group (32 subjects) was taught using minimal lecture supplemented heavily with audio-visual material while the control group (36 subjects) was taught using a conventional lecture with no audio-visual material. The same instructor was used to teach both groups. The audio-visual material consisted of: 1) 16mm motion picture film w/sound, 2) 35mm slides, 3) sound/filmstrips, and 4) overhead transparencies.

The experimental group had a mean point average of 2.56 while the control group had a mean of 2.67. Brum compared the final grade point averages of the experimental and control groups using a t-test. The results were not significant at the .05 level. Brum concluded that the audio-visual supplemented lecture was as good as the traditional lecture method but not necessarily better.

Audio-visual aids have been used extensively to teach concepts. Concepts can be taught and acquired by using two basic modes of presentation: induction or deduction. Koran (21) and others explored the effectiveness of these modes of presentation as well as the effects of exposure time on the acquisition of a biology concept.

The sample used for this experiment was 339 high school students randomly assigned to six groups. The treatment for each group was presented by slide-tape and consisted of a mode of presentation (inductive or deductive) with varying intervals of time for each mode. The treatment for each group was: 1) inductive, five second exposure, 2) inductive, eight second exposure, 3) inductive, five second exposure, 4) deductive, five second exposure, 5) deductive, eight second exposure, and 6) deductive, fifteen second exposure.

The slide-tape program consisted of 48 slides divided into six major categories: 1) introduction (five slides), 2) mode of instruction (one slide), 3) instruction for use of examples (one slide), 4) positive or negative example (twenty slides), 5) instruction for posttest (one slide), and 6) posttest (twenty slides). The slide presentation was virtually the same for both the inductive and deductive groups except for the mode of instruction slide. For the inductive group, the mode of instruction slide required the subject to induce the type of flowering plant (monocot or not) while the deductive group was told the characteristics of a monocot and had to deduce the type of flowering plant.

A 2 x 3 factorial design (two treatment groups- inductive, deductive; three treatment times- 5, 8, 15 seconds) was used to compare the effectiveness of the experimental variables. A two-way analysis of variance was performed on the experimental data. The results of the analysis indicated significance for both treatment type ($p < .01$) and treatment time (15 seconds- $p < .05$). Koran concluded that the deductive method was more effective in teaching a relatively simple biological concept. He and his colleagues also concluded that as exposure time increased for either mode of instruction, the amount of learning also increased.

Studies have been completed that confirm the hypothesis that bimodal media presentations are more effective than unimodal media presentations. Nasser and McEwen (23) compared the effects of bidmodal media presentations (television, audio-print) on recall and involvement to that of unimodal presentations (print, audiotapes).

Nasser and McEwen postulated that videotape (television-bimodal presentation) would elicit higher recall and involvement than audio or print (unimodal presentations). They also hypothesized that a message presented by audio-plus-print (bimodal presentation) would have a greater effect on involvement and recall than print or audio alone.

The experiment was a one-by-four (1 x 4) after-only design consisting of four groups: 1) audio alone, 2) print alone, 3) audio-plus-print, and 4) videotape. The subjects (N=100) were randomly assigned to one of the four groups. The subjects were exposed to the treatment variables and were subsequently posttested on recall of information and feelings of involvement.

The videotaped version of the message was presented by a graduate student and videorecorded in black-and-white. The audio version was recorded directly from the videotaped message while the audio-plus-print message included a written transcript on slides. The print version of the message consisted of a slide transcript that could be manipulated by the subjects using a hand control on a projector.

The test instruments used to measure recall was developed by Nasser and McEwen. The questions had been evaluated and were found to discriminate between subjects on post-exposure recall. Involvement was measured using an instrument developed by Krugman and Leavitt with additional items developed by the investigators.

The results of the experiment indicated that the bimodal presentation (audio-plus-print) was significantly more effective (p=.03) in eliciting recall than unimodal presentations (audio). The videotaped presentation was more effective (p=.07) in eliciting recall than audio while audio-plus-print was slightly more effective (p=.09) than print alone. The involvement portion of the experiment resulted in two significant findings that contradicted the hypotheses postulated by the experimenters. The print condition created more involvement arousal than either videotape or audio-plus-print (p=.03, p=.04 respectively) (23, p. 270). Nasser and McEwen concluded along with other experimenters that recall increases with additional channels of information; however, additional channels of information do not necessarily indicate that there will be an increase in felt involvement.

A concern of many media researchers is the effectiveness of color in a still presentation. Dwyer (13) performed an experiment that investigated the effects of IQ level on the instructional effectiveness of black-and-white and color illustrations. The purposes of this study were fourfold: 1) to determine the effect of IQ level on the instructional effectiveness of black-and-white and color used to complement oral instruction; 2) whether all types of visuals are equally effective if facilitating student achievement of identical educational objectives; 3) whether identical visuals are equally effective in facilitating student achievement on different criterion measures; and 4) whether color is an important instructional variable in illustrations used to complement oral instruction (13, p. 51).

The sample population for this study was 508 students enrolled at Pennsylvania State University. The subjects were classified as having high, medium, or low IQ's using the Otis Quick-Scoring Mental Ability Test (Form Fm). Students were randomly assigned to eight groups with each treatment group receiving oral instruction by an audio tape recording. The only difference among the groups was the type of pictorials used to complement the oral instruction.

Eight types of pictorials were displayed to the groups by a slide projector that advanced in sequence with an audio tone embedded on the tape. The pictorials consisted of: 1) simple line presentations (b&w), 2) simple line presentations (color), 3) detailed, shaded drawings (b&w), 4) detailed, shaded drawings (color); 5) heart model presentation (b&w), 6) heart model presentation (color), 7) realistic photographic presentation (b&w), and 8) realistic photographic presentation (color).

Five criterion measures were used to measure the effectiveness of the treatments. The criterion were: 1) a drawing test, 2) an identification test, 3) a terminology test, 4) a comprehension test, and 5) a total criterion test (78 items) which was a composite of the individual criterion tests.

A 3 x 8 ANOVA (three levels of IQ, eight visualized treatments) was performed to determine the significance of the treatments. The results of the study showed: 1) not all visuals were equally effective in facilitating student achievement on different criterion tasks, 2) students in the high IQ level scored consistently higher on criterion measures than the medium or low IQ students, 3) realism in pictures is not a reliable predictor of learning efficiency, and 4) the simple line drawing presentation (color) to be the most effective in terms of effectiveness, economy, and simplicity of production (13, pp. 59-60).

There has been some controversy over the effectiveness of the addition of background music to audio-visual materials. Raburn and Tysor (31) studied the effects of background music on lecture tapes, filmstrips, and films in teaching freshman psychology concepts.

The researchers selected three university psychology classes for the experiment. The students were not randomly assigned to the classes so pretests were administered to determine the knowledge of the subjects at the time of the experiment. All experimental subjects viewed three methods of presentation: film, filmstrip, and lecture tape. During the experimental period, group one had music at presentation time, group two had music at presentation time and testing time, and group three was a control group and had no music except that which was present on the commercial product.

For comparison purposes the subjects were divided into groups of males, females, visuals, and non-visuals (haptic). A variety of statistics were used to determine the effects of the background music on the subjects. Overall, the researchers tentatively concluded that music can be a good addition to visual and/or verbal presentations. However, the addition of music to music already present on a film or filmstrip is unnecessary. The researchers also concluded that all forms of the media used were efficient methods for teaching facts to the students so that they could achieve acceptable scores on a multiple choice test (31, p. 540).

Computer assisted instruction.--Computer assisted instruction (CAI) became a viable instructional technology when main frame computers became available to post-secondary institutions in the early 1970's. Two of the earliest CAI systems evaluated on an experimental basis by the Educational Testing Service (ETS) was PLATO and TICCIT (17).

PLATO (Programmed Logic for Automatic Teaching Operations) was developed in the early 1960's at the University of Illinois. The PLATO system consists of a mainframe computer to which a series of terminals are connected through a network of telephone lines. The terminals are of a special type in which a touch-sensitive screen is used to input data along with the standard keyboard.

The PLATO system was developed by the Center for Electronic Resources Laboratory (CERL). CERL initially decided to test the system in a community college setting because of the sizable enrollments and the large number of introductory courses (17, p. 4). The courses originally developed by CERL were basic accounting, biology, chemistry, English, and mathematics. The experiment lasted two years (1974-1976) with four to five thousand students participating each semester.

ETS analyzed the data produced by the subjects involved in the PLATO system. Conclusions drawn on the effectiveness of the PLATO system by ETS were both positive and negative. Conclusions reached by ETS on the PLATO system were:

1. Dropout rates were not significantly reduced by the Plato system. Course completion depended primarily on initial ability.

2. PLATO was neither helpful nor harmful to student achievement.

3. Generally, students were positively impressed with PLATO.

4. Instructors' attitudes towards the PLATO system were generally favorable.

ETS suggested that the system be continued even though no positive or negative effects on achievement or dropout rates could be discerned. The PLATO system should be voluntary for students with more help sequences in lessons and less stringent answer judging routines (17, p. 6).

At the same time PLATO was being developed, TICCIT (Time-Shared Interactive, Computer-Controlled Information Television) was being installed and evaluated in Virginia and Arizona. TICCIT was fundamentally different in its approach to CAI curriculum; PLATO was designed to supplement traditional teaching methods, while TICCIT was used to replace traditional teaching methods.

The computers used for the TICCIT system were minicomputers that had keyboards for input and color televisions for output. The software was developed at Brigham Young University by The Institute for Computer Use in Education (ICUE). The TICCIT software was employed at community colleges in Washington, D.C. and Phoenix, Arizona. The evaluation of the system was done by ETS and lasted two years (1975-77). The student base for the evaluation consisted of 5,000 students enrolled in over 200 sections of five different academic areas.

ETS made some rather interesting discoveries about the effectiveness of CAI on course completion rates and student achievement. The course completion rate for certain subjects, in particular mathematics, was extremely poor. The average completion rate for the TICCIT mathematics sections was 16 percent compared to 50 percent for non-TICCIT sections (17, p. 8). Student achievement on posttests was generally higher in the TICCIT sections than in the non-TICCIT sections. This was especially true in Algebra where the posttest scores in the TICCIT sections were 10 percent higher than the non-TICCIT sections. ETS concluded TICCIT does not support the needs of the ill prepared student, but may be a cost effective technique for students with stronger academic backgrounds. The PLATO and TICCIT systems are still being used; however, with the development of the microcomputer, CAI has become a truly effective teaching technology.

Until the middle seventies, computer assisted instruction was a form of technology that few educational institutions could afford. With the advent of the microcomputer, CAI became an affordable alternative to traditional teaching methods. Microcomputers are utilized in CAI as an individualized teaching method that employs the basic concepts of programmed instruction. The microcomputer can present information in small steps, have the student actively respond to instruction, and provide immediate feedback (8, p. 23).

In the last five years there have been many studies on the effectiveness of CAI. Ploeger (30) reviewed over 1,200 article titles and abstracts on the uses of microcomputers in education and compiled the most important twenty-two research topics into a booklet. According to Ploeger, "research has clearly demonstrated that instructional microcomputing can be a valuable educational tool" (30, p. 18). Microcomputers can enhance the affective measures such as motivation and self-esteem while time-on-task may increase and problem solving strategies may be changed. Learning the BASIC programming language helped to improve math skills while the studies on the use of LOGO indicated no increases in math or reasoning skills. Ploeger suggests microcomputers be a supplement to traditional teaching methods and, if used in an appropriate manner, may lead to satisfactory results.

Computer assisted instruction has been compared to more traditional forms of teaching. Dunkel (12) compared the effectiveness of CAI to a self-study, slide-tape program. Both the CAI and self-study program were extracurricular supplements to a traditional lecture on medical terminology.

Subjects were randomly assigned to control and experimental groups. The CAI experimental group consisted of 22 subjects while the control group (slide-tape) consisted of 24 subjects. A t-test was used to determine significance between the experimental and control group final scores. At the .05 level there was no significant difference found between the two groups. Since there was no significant differences between the two methods, Dunkel recommended that teachers assign students to the CAI or slide-tape program according to their individual preferences.

In another study, Brown (5) compared the effectiveness of microcomputer based CAI on study skills instruction to traditional printed materials. The sample for the study consisted of 421 freshman students enrolled in two orientation classes at a southwestern university. The computer (experimental) group totaled 149 students while the print (control) group consisted of 272 students.

The material presented by the CAI method and the print method were identical except for some minor changes in wording to fit the method of instruction. The criterion measure used for this experiment was the *Survey of Study Habits and Attitudes* and was administered to all subjects as a pretest and as a posttest. Chi square was used to determine the effectiveness of the two methods.

Brown determined that both methods (computer and print) were equally effective in improving the self-reported study habits and attitudes of freshman students (5, p. 4). The gain scores for both methods were significant at the .001 level. Student acceptance for the two approaches was also favorable. Brown concluded that both methods were equally effective and accepted. Since initial investment in CAI hardware and software can be substantial, Brown recommends that research should be done prior to the installation of a microcomputer based CAI system to ensure that the system meets the needs of the learner.

Group applications for CAI have been studied on a limited basis. Okey and Major (25) studied the effects of CAI on individuals and small groups. In the study, sixty students were randomly assigned to one of three groups. The subjects received instruction via terminals connected to PLATO. Group one subjects studied individually, group two subjects studied in pairs, and group three subjects studied in subgroups of three or four. The subject matter for the experiment was Bloom's mastery learning strategy.

The dependent variables for the study were a cognitive test over the subject matter, study time for each group, and an attitude questionnaire covering tests, testing, and diagnostic teaching. The reliability for the attitude questionnaire was .58.

One-way analysis of variance was used to determine the effectiveness of the three CAI groups. At the .05 level there were no significant differences among the groups in either the cognitive test or attitude questionnaire; however, the study time for subjects studying in groups of three or four was significant at the .01 level. The study time for the groups of three or four was 22.73 minutes less than the subjects that studied individually, and 39.53 minutes less than the subjects that studied in pairs.

The researchers concluded that learning can take place when multiple users employ CAI. The groups did equally well on a cognitive test and an attitude questionnaire but the multiple user group required significantly less time to learn the material. Since computer time can be expensive the researchers recommended that small groups be used when costs must be kept to a minimum.

Pretest and Sensitization Effects

A concern that many educational experimenters have is the effect of pretesting on the outcome of an experiment. The administration of a pretest is customarily done to: 1) detect differences among groups in experimental designs, and 2) assess the initial cognitive characteristics or attitudes of a group or groups.

The administration of a pretest could possibly introduce biases in the posttest outcomes. These biases are referred to as "pretest effect" and "pretest sensitization" (37, p. 605). Pretest effects cause the results of an experiment to be biased because of item-practice, while pretest sensitization leads to higher posttest scores for those subjects in an experimental group because they learn from the pretest the type of material to concentrate on.

Welch and Walberg (37) conducted an experiment on the effects of pretesting in curriculum evaluation. In their review of the related literature, they listed ten studies on the effects of pretesting. Most of the studies were of a short duration (one hour to twelve weeks) and were primarily concerned with attitude and opinion changes. Four studies indicated no effect of pretesting on outcomes, three indicated a positive effect, while the remaining showed a depressive effect (37, p. 606). Welch and Walberg concluded that the studies prior to 1970 were not representative of curriculum experiments and that research on the effects of pretests on curriculum evaluation were non-existent.

Welch and Walberg examined the effects of pretesting and sensitization on the evaluation of an experimental physics curriculum. They hypothesized no pretest effects and no pretest-treatment interaction (sensitization).

The experiment was conducted over an academic school year (seven months). Six criterion measures (three cognitive, three affective) were used to evaluate the effectiveness of the curriculum. The sample consisted of 2200 students to which 57 teachers (36 experimental, 21 traditional) were randomly assigned. For statistical purposes the subjects were divided into four groups: 1) pretested experimental, 2) pretested control, 3) non-pretested experimental, and 4) non-pretested control. A 2 x 2 non-orthogonal analysis of variance was used to examine the pretest and sensitization effects.

The results of the experiment indicated significance at the .05 level on three of the six treatment effects. The effects of pretesting and the sensitization effect was not significant at the .05 level for any of the six criteria. Welch and Walberg concluded that for over relatively long periods of time, pretest and sensitization effects are not serious problems in the normal classroom environment.

Other researchers have examined pretesting effects and have arrived at somewhat different conclusions. Wilson and Putnam (38), for example, performed a meta-analysis on 33 studies dealing with pretesting and sensitization. The analysis concentrated on variables extracted from the studies. The variables investigated were: 1) year of publication, 2) subjects' grade in school or age, 3) sex of subjects (all males, all females, or mixed), 4) duration of time between pretest and posttest, 5) citation (or not) of test reliability, 6) sample size, 7) randomization or nonrandomization in selection of subjects, 8) random or nonrandom assignment of subjects to groups, 9) presence or absence of relevant treatment between pretest and posttest, 10) category of dependent variable, 11) similarity or dissimilarity of pretest and posttest, and 12) effect size of pretest and posttest (38, p. 250).

To determine effect size, variables were analyzed using correlation, regression, and analysis of variance. After initial analysis of the data the researchers concluded that non-randomized studies were systematically biased and were not included in the remainder of the study.

The results of the analysis indicated that time between pretest and posttest had an effect on the outcome. Time intervals of a few days to two weeks had larger effects than time intervals shorter than one day or greater than one month. Pretesting had a significant positive effect on cognitive and attitudinal outcomes. These results tend to contradict the findings of Welch and Walberg (38, p. 255). Wilson and Putnam concluded that a general pretest effect exists which could not be overlooked and pretest effects do not seem to be consistent across the psychological domains.

Summary

This chapter reviewed five major literature areas. The areas reviewed were: 1) industrial robots, 2) personal robots, 3) robots in education, 4) instructional media, and

5) pretest effects. These areas were reviewed because the knowledge derived was essential for the proper execution of the experiment.

Industrial robots are becoming a potent force in industry because they are replacing workers in jobs that are boring, tedious, or dangerous. Industrial robots also increase productivity because they need no breaks, work 24 hours-a-day, and require little environmental protection such as heating or air conditioning. The number of industrial robots is expanding quickly so there will be a growing need for people to maintain and program them. It will be the job of the community colleges and vocational-technical schools to produce the quantity and quality of people required.

Personal robots are primarily used by technical hobbyists and educators and are classified as arms, mobiles, or turtles. Educators are using arms and mobiles to teach the fundamentals of robotic technology. Arms and mobiles are ideal for this purpose because they are comparatively inexpensive and less hazardous than full-size industrial robots.

Robots are not being used to a great extent in general education. The primary applications of robots in general education have been limited to being used as a supplementary educational tool for the teaching of programming and mathematics. Educators such as Papert (27, 28, 29), Delgado (10), and Watt (26) have used personal robots to teach mathematics and computer programming to grade school students on an individualized or small group basis. Experimental research on the effectiveness of robots as teachers is non-existent. The researcher could not find any experimental studies on the use of personal robots to teach a group of students in a manner similar to that of a teacher giving an oral lecture supplemented with visual aids.

Instructional media has been used to replace or supplement traditional teaching methods. Instructional media studies completed by Rankowski and Galey (32), Biekert (4), Rayburn and Tysor (31), and Brum (6) have verified the effectiveness of media presentations.

There are many factors that determine the effectiveness of media presentations. Koran (21) and others determined that a deductive approach to media presentation is preferable to induction when teaching simple concepts. Koran and his colleagues also determined that increased exposure time to media will increase the amount of learning. Nasser and McEwen (23) concluded that increased channels of information increases the ability to recall information while Dwyer (13) demonstrated simple, color, line drawings to be most capable in terms of effectiveness, simplicity of production, and economy. The inclusion of background music can be a good addition to visual and/or verbal presentations; however, the addition of music when music is already present on a filmstrip is unnecessary (31).

Computer assisted instruction (CAI) has become an important teaching technology in the last ten years. Studies in the mid 1970's determined that mainframe CAI is an effective supplement to traditional teaching methods (17).

Since the invention of the microcomputer, CAI has become affordable to most educational institutions. Comparison studies completed by Dunkel (12) and Brown (5) have shown that microcomputer based CAI is as effective as traditional individual teaching methods.

Studies of the group effectiveness of CAI has been very limited. Okey and Major (25) completed a studied in which a small group of students were exposed to CAI. Okey and Major concluded that a small group (3 students) did as well as individuals on cognitive tests and groups should be used when costs for equipment must be taken into account.

A major threat to external validity is pretest interaction and sensitization. Studies on the effects of pretesting have yielded conflicting results. Welch and Walberg (37) performed a study on the effects of pretesting on a new type of physics curriculum. They concluded that pretesting effects are not significant when the treatment lasts for relatively long periods of time. Wilson and Putnam (38) performed a meta-analysis on studies related to the effects of pretesting. Their results conflicted with those reached by Welch and Walberg. Wilson and Putnam concluded that pretest effects are significant and should not be overlooked when performing experimental studies.

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CHAPTER III

METHODOLOGY

The purpose of this chapter is to describe the methodology required to complete the experiment. The chapter includes the test instrument, pilot study, subjects, data gathering methods, and procedures for analyzing data. This experiment was a Solomon Four-Group Design and was based upon procedures outlined in *Experimental and Quasi-Experimental Designs for Research* (2, pp. 24-25). A t-test for correlated means was used to test the first two hypotheses while two-way analysis of variance was utilized to test the level of significance for the remaining three hypotheses. The experiment was conducted at Southeastern Oklahoma State University during the fall semester of the 1985-1986 school year.

Test Instrument

The robot used in this experiment presented a series of sound/filmstrips on robotic technology entitled *Robotics*. The researcher contacted the Library Filmstrip Center, the company that developed the filmstrip series, and discovered that no test instrument had been developed.

The filmstrip consisted of six modules with each module covering a specific topic related to robotic technology. By carefully listening to the audio portion of the filmstrip and observing the accompanying image, 159 multiple choice questions were written that reflected the major concepts presented in the Robotics Filmstrip Teacher's Guide (4).

Test content validation was accomplished by having a panel of experts view the filmstrip series. (See Appendix C.) After viewing a module, the experts evaluated the module questions using a scale that ranged from 1 (poor) to 5 (excellent). A simple BASIC program was written that computed and printed the average value for each question.

Originally, questions were going to be eliminated if the question average was less than three; however, after initial evaluation only two questions would have been eliminated using that criterion. After consultation with the panel of experts, the researcher decided to use the 16 highest rated questions for each module. The outcome of the content validation resulted in a six module multiple choice test of 96 questions in length. (See Appendix E.)

The reliability of the test instrument was measured using the split-half technique (3, p. 120). The test was administered to 104 students (seven randomly selected university classes). All answers were placed on a computer test form by the students and graded using odd and even keys. The resulting odd and even scores for all participants were placed in two lists and submitted to a microcomputer program (6, p. 38) for a Pearson product-moment correlation. The results of the analysis indicated a

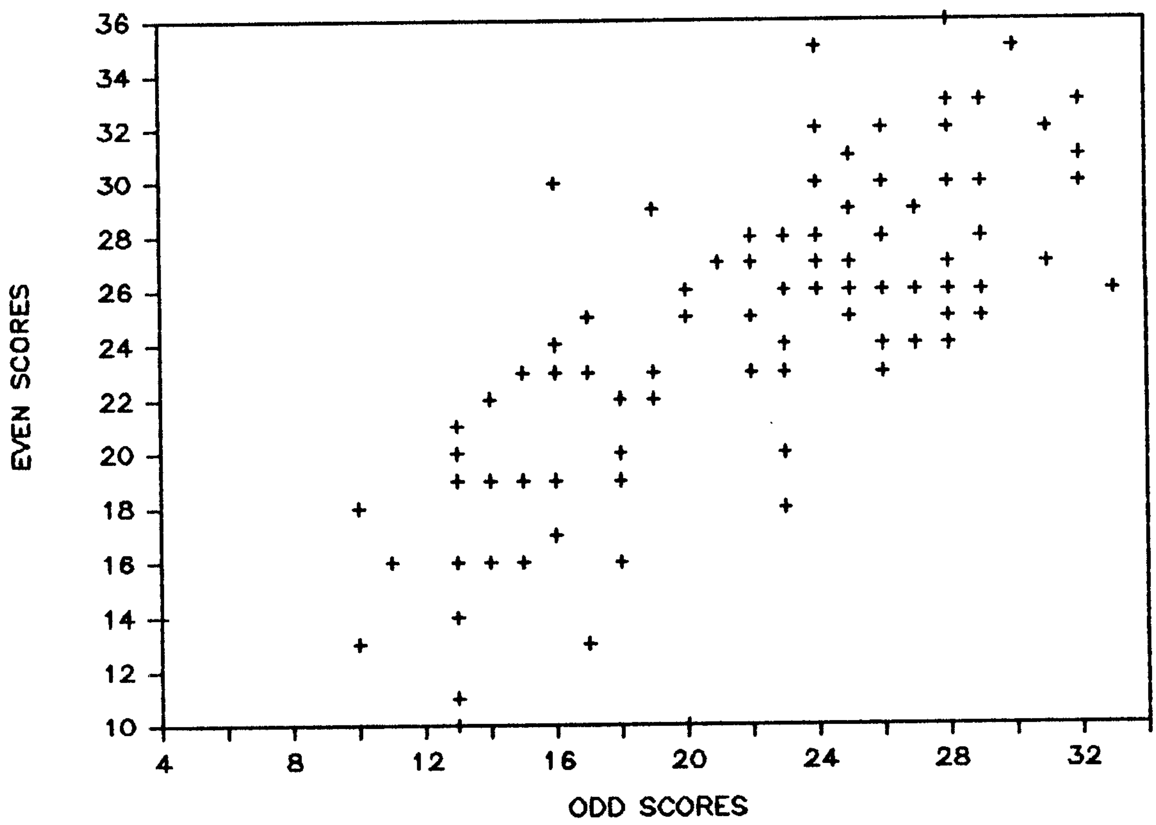

Fig. 3--Scatter diagram of odd and even scores

correlational value of .75. The correlational value was inserted into the Spearman-Brown prophecy formula which resulted in a split-half reliability coefficient of .86. According to Morris and Fitz-Gibbon (5, p. 114) a reliability coefficient of .70 or higher is considered respectable. Figure 3 is a scatter diagram of the data and indicates a positive correlation between the odd and even test scores.

An ex-post facto correlation was carried out on the posttest scores and delayed retest scores. The correlation coefficient of .94 resulted from the analysis. This value suggests a high test-retest reliability. Figure 4 is a

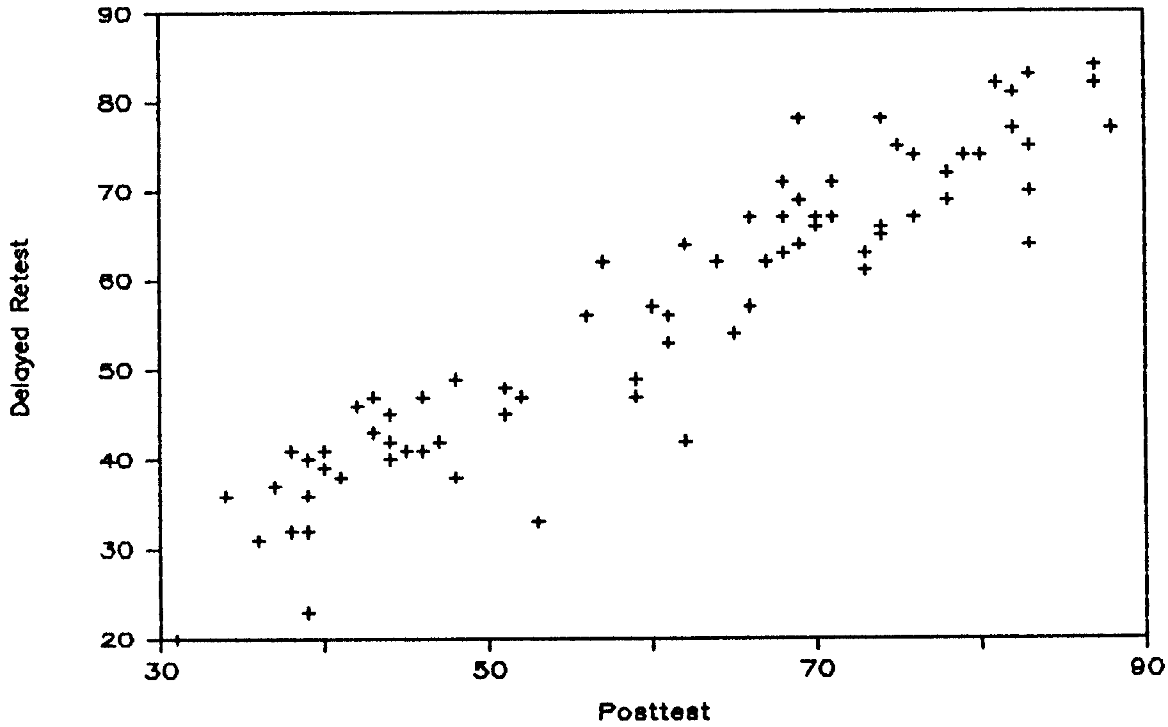

Fig. 4--Test-retest reliability using posttest and delayed retest scores.

scatter diagram of the data and clearly indicates a high positive correlational value between the two variables.

<u>Pilot Test</u>

A pilot test was conducted approximately six weeks prior to the execution of the experiment. The purpose of the pilot test was to: 1) determine the electrical and mechanical characteristics of the robot, 2) determine the programming required to make the robot perform its assigned tasks, 3) determine the reaction of subjects to the robot and filmstrip, and 4) elicit suggestions from colleagues and students on methods to improve the performance and presentation of the robot and classroom monitor. The pilot test was conducted using a posttest-only, control group design (2, pp. 25-26). (See Table V.)

TABLE V

POSTTEST-ONLY, CONTROL GROUP DESIGN

Experimental Group	R	X	O
Control Group	R		O

Two classes were selected from the Electronic Technology Department and randomly assigned to experimental (N=20) and control (N=12) groups and shown the filmstrip, "Robots In Industry." The control group was shown the filmstrip by a human being while the filmstrip shown to the experimental group was controlled by a robot.

Experimental treatment.--The experiment began by having the subjects come into the classroom and sitting at the tables. (See Figure 5.) Faculty members from the Division of Industry were present as observers but did not participate in the experiment. The classroom monitor (the researcher) introduced himself and explained the purpose of the experiment. After the explanation, the classroom monitor proceeded to the fabrication room and loaded the microcomputer program into the robot. The program loading took approximately five minutes to complete.

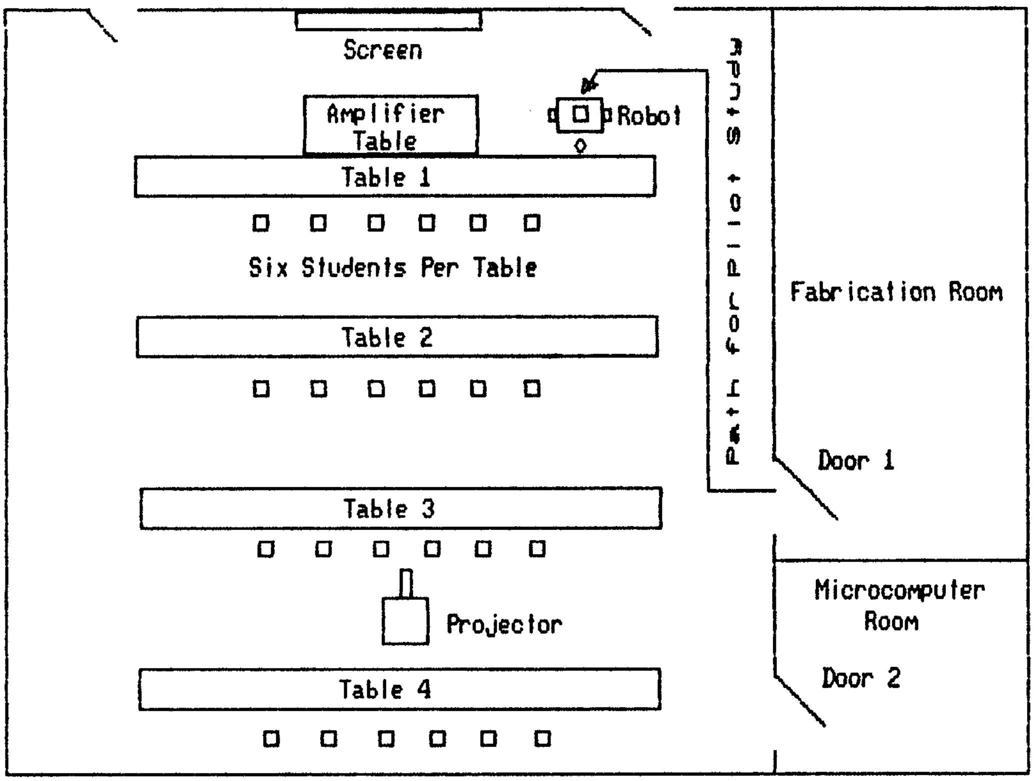

Fig 5.--Pilot test robot path

When the program was loaded and executed, the robot moved out Door 1 and along the intended path. (See Figure 5.) The robot reached the front of the classroom and activated its internal tape recorder. A prerecorded message introduced the filmstrip and requested the classroom monitor to turn the lights off and start the projector. After the lights were extinguished, the filmstrip audio began and the projector was advanced in sequence with the filmstrip by the classroom monitor.

Upon completion of the filmstrip the robot requested that the projector be turned off and the lights turned on. The robot then proceeded to give instructions for taking the posttest. The subjects were given ten minutes to complete the posttest and were timed by the robot's microcomputer. At the completion of the test the subjects were told by the robot to put down their pencils and wait until it returned to the fabrication room. Once the robot returned to the fabrication room, the classroom monitor requested the subjects and faculty members remain so that suggestions could be procured.

A number of suggestions were produced by the faculty and subjects. Three major suggestions were voiced by the participants: 1) improve the quality of the sound produced by the robot, 2) improve the lighting conditions of the room, and 3) decrease or eliminate the need for human interference.

The audio output of the robot's internal cassette recorder originally was fed to an amplifier that drove a small speaker mounted in the throat of the robot. The problem with this scheme was that it was very difficult to adjust the cassette volume so that the amplifier was not overdriven. The solution to this problem was to modify a cassette recorder so that the amplifier of the cassette was used to drive a speaker directly.

The classroom in which the filmstrip was presented had eight large windows with no shades. The light from the outside shone directly into the faces of the students and made it very difficult to view the media. To reduce glare and keep lighting conditions uniform, black cardboard was placed over all glass windows.

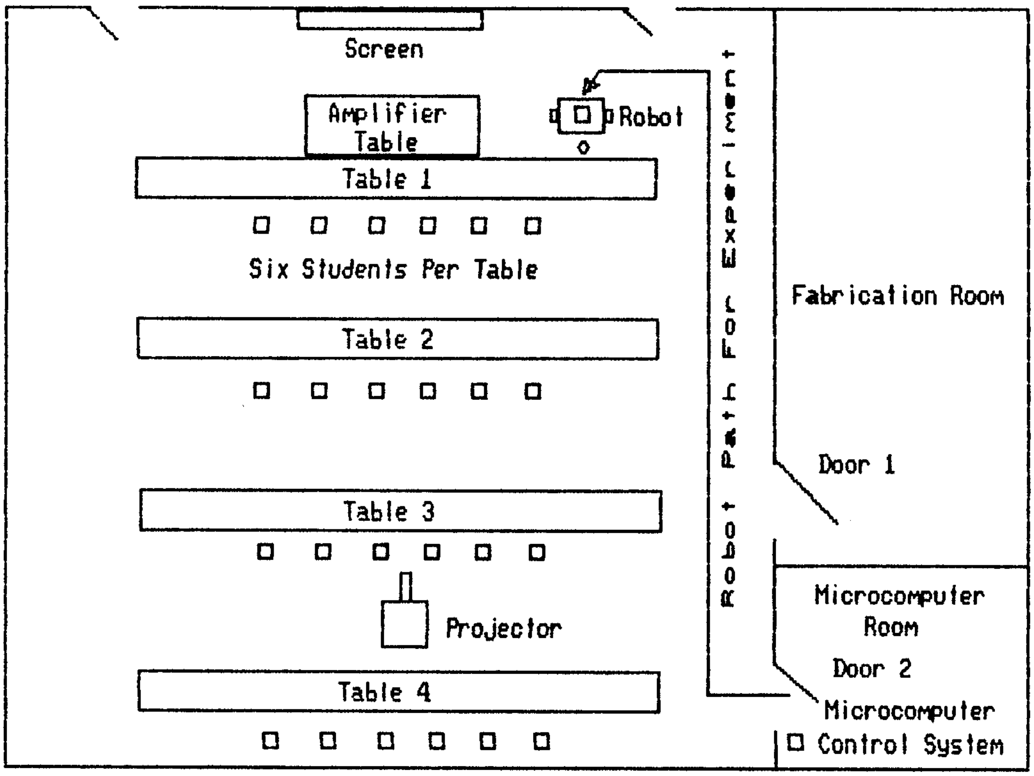

Fig 6.--Experimental robot path

To improve the presentation so that human interference was kept to a minimum, a computerized command system was developed that allowed the robot to control the lights and projector from a remote location. (For a complete description of the control system see Appendix B.) The master computer for the system was located in the microcomputer room. This location required that the path of the robot be altered for the experiment. Figure 6 shows the new path the robot had to follow.

Control treatment.--The control group and two faculty members were brought into the classroom by the monitor (researcher). The monitor introduced himself, explained the purpose of the experiment, and proceeded to extinguish the lights. The filmstrip projector was started and manually advanced by the monitor in sequence with the cassette's audio tone. At the end of the filmstrip the lights were turned on and the projector turned off. The instructions for the taking the posttest were explained and ten minutes were allowed for completion of the examination. Upon completion, the subjects and faculty members were asked to remain and submit suggestions for improving the presentation.

The primary complaint of the control group was the poor audio emitted by the filmstrip projector. The problem was corrected by using an external cassette recorder, identical to the one carried by the robot. For the experiment, the cassette recorder was placed on a movable table and placed in front of the classroom. The table was then moved by the monitor to the position used by the robot and a microphone was placed near the cassette's speaker so that the sound could be heard clearly throughout the classroom.

A faculty member who observed the the experimental group suggested that the monitor follow the same path as the robot. When the experiment was conducted, the monitor would initially admit the subjects into the classroom and then proceed to the control room where he waited until all subjects were seated. After all subjects were in place, the monitor would exit the microcomputer room and follow the path used by the robot.

Pilot test outcome.--Table VI gives the descriptive statistics for both the experimental and control groups posttest scores. The experimental group's mean (13.20) was slightly lower than the control group's mean (13.83).

TABLE VI

PILOT TEST DESCRIPTIVE STATISTICS

Group	Mean	Standard Deviation	N
Experimental	13.20	1.85	20
Control	13.83	1.64	12

Posttest scores were tested for significance using one-way analysis of variance. Table VII gives the results of the analysis. From the table it can be seen that the means were not significant at the .05 level (p=.34).

Even though the analysis indicated no significant difference between the two group means, it did indicate that the robot presentation was at least as good as the presentation given by the human being. With improvements in the robot presentation and a larger and more random selection of subjects, it seemed possible for the robot to do a better job in presenting the filmstrip than a human being.

TABLE VII

PILOT TEST ONE-WAY ANALYSIS OF VARIANCE

Effects	SS	df	MS	F	p
Between	3.01	1	3.01	.95	0.34
Within	94.88	30	3.16		

Subjects

Subjects for this experiment were procured through the solicitation of volunteers. Permission was obtained from the Division of Industry chairman (see Appendix F) to recruit students for the experiment. The procedure listed in Borg and Gall (1, p. 255) was used to maximize the volunteering rate.

Approximately four weeks before the beginning of the experiment, advertisements for volunteers were placed in conspicuous locations throughout the Division of Industry.

(See Appendix G.) Faculty members also spoke to their classes about the experiment. A volunteer list was posted on the researcher's office door so that students could sign-up if they so wished. Approximately twenty subject's names were obtained in this manner.

One week after the posting of the advertisements, the researcher began visiting classes within the Division of Industry and expressed to the students the importance of volunteering and the need for volunteers. A volunteer list was circulated at the end of the recruiting session so that students could volunteer immediately. The researcher visited classes in the division for one week during which time 84 students volunteered to participate in the experiment. The total number of students that volunteered for the experiment was 104.

Three weeks before the experiment, a mass meeting for all volunteers was held in room A100 of Southeastern Oklahoma State University's Administration building. The purposes of the meeting were to discuss the experiment with the prospective volunteers, assign the volunteers to their respective groups, and to pretest Groups I and II.

The prospective subjects were told the purposes of the experiment , essentially how the experiment was going to be conducted, and their responsibilities if they decided to volunteer. Subjects were informed that the activity was entirely voluntary and they had the right to dropout of the experiment at any time without penalties. Subjects who volunteered were given excuses from the Vice President of Instruction so that they could participate in the experiment without penalties for missing classes. (See Appendix H.)

A microcomputer program (see Appendix D) was written that randomly assigned the volunteers to four groups of equal size. The microcomputer program produced a printout of the individual's name and the group to which the volunteer was assigned. These printouts were cut into small slips and distributed to the volunteers at the meeting. Table VIII shows the number of subjects that were present at the mass meeting, those that attended the first experimental session, and the number that actually completed the experiment.

TABLE VIII

VOLUNTEER COMPLETION RATE

VOLUNTEERS	GP1	GP2	GP3	GP4	TOTALS
Mass meeting	26	26	26	26	104
First experimental session	25	22	23	25	95
Completed experiment	21	20	19	24	84

After the subjects were assigned to the various groups, a schedule for the experiment was given to the participants and all subjects were required to sign and have witnessed the form, USE OF HUMAN SUBJECTS. (See Appendix I.) This form was collected and filed in the researcher's office.

Upon completion of the form, Groups III and IV were allowed to leave while Groups I and II were required to take a pretest. The pretest was a concatenation of the individual module tests. The pretests and computer answer forms were distributed to the subjects and test instructions were given by the researcher. The subjects were given one hour to complete the test with no one being allowed to leave until the period was over.

After the participants had completed the pretest, the tests and answer forms were collected and brought to the Engineering Technology building. The answer forms were machine graded and the results were stored in an electronic spreadsheet for later analysis.

Procedures for Collecting Data

The design utilized for this study was a Solomon Four-Group Design. The subjects for this experiment were divided into four groups according to the procedures listed in Campbell and Stanley (1, p. 24). Table IX shows the group assignments, treatment type, and tests administered to the subjects.

The experiment was conducted in Room 303 of the Engineering Technology building at Southeastern Oklahoma

State University. The experiment began on November 4, 1985, and continued for a period of six consecutive class days. (See schedule in Appendix I.) The experiment began at 8:00 AM and ended at 12:00 PM with each session lasting one hour. Before each experimental session module tests, computer answer forms, and pencils were laid out on the classroom tables.

TABLE IX

EXPERIMENT GROUP ASSIGNMENT, TREATMENT TYPE AND TESTS ADMINISTERED

Group #	Pretest	Treatment Type	Posttest	Delayed Retest
I	Yes	Experimental	Yes	Yes
II	Yes	Control	Yes	Yes
III	No	Experimental	Yes	Yes
IV	No	Control	Yes	Yes

Experimental treatment.--The experiment began on a Monday with Group I (experimental) being shown the module, "Robots In Industry." The robot was programmed to show the filmstrip prior to the subjects entering the room. Once the subjects were seated, the researcher engaged the robot's motors and it moved from the microcomputer room into the classroom. The robot proceeded along the path shown in Figure 7. After the robot reached the front of the classroom, it greeted the students (see Appendix J for robot's speech), extinguished the lights, and started the projector. The robot began the filmstrip presentation and advanced the projector in sequence with an audio tone embedded in the cassette tape.

Upon completion of the filmstrip the robot turned the lights on and the projector off. It then gave instructions for taking the module test and timed the students for ten minutes. At the end of the test period, the robot told the subjects to remain seated until it had returned to its final

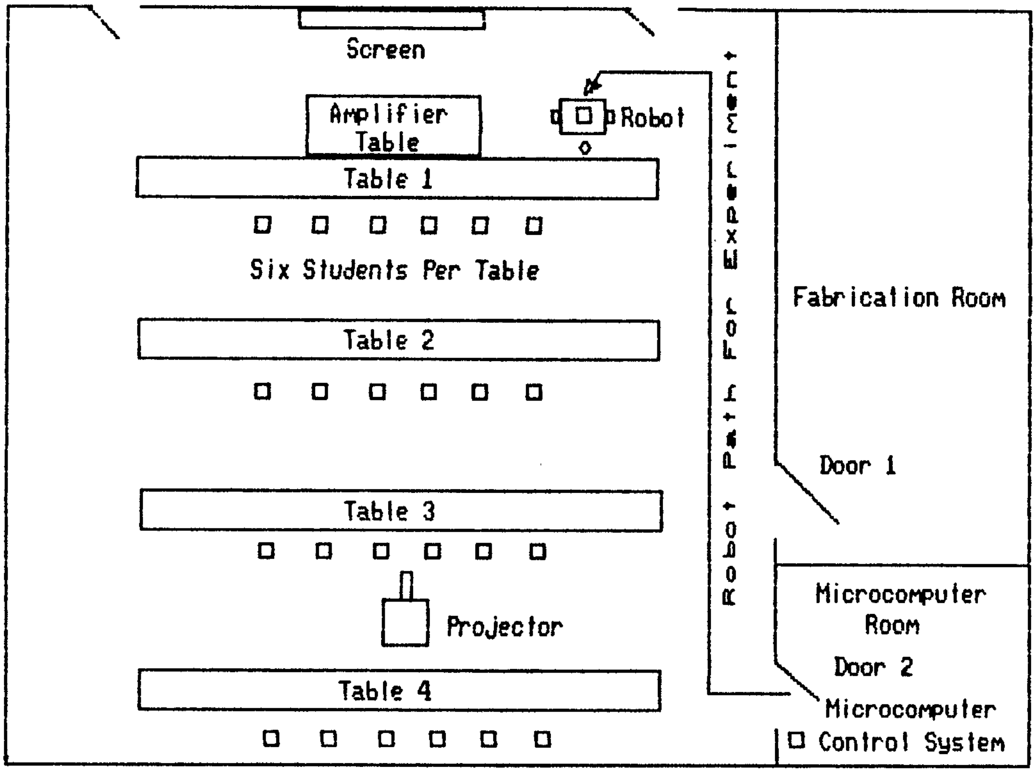

Fig 7.--Robot Path

position. Once the robot reached its final position, the subjects left the classroom. The researcher then prepared for Group II by: 1) collecting answer forms and storing them in folders, 2) changing the projector to manual control, and 3) distributing new computer answer sheets. The robot was also moved to its starting position and the battery replaced for the next experimental group.

Control treatment.--Group II was admitted into the classroom by the monitor (researcher). After all subjects were seated, the monitor began the filmstrip presentation by exiting the control room and following the identical path as the robot. Once he reached the front of the classroom, a cart with the cassette recorder was moved close to a microphone. The monitor then introduced the module using a written speech. (See Appendix J.) After the introductory speech, the monitor: 1) switched the projector on, 2) turned the lights off, 3) activated the cassette recorder, and 4) advanced the filmstrip projector manually in sequence with the audio tone.

At the end of the filmstrip, the monitor turned the lights on and the projector and cassette recorder off. Instructions were given for taking the test which was timed for ten minutes using a watch. After the subjects were allowed to leave, all computer answer forms were collected and stored in a folder, the projector was changed over for remote control, and the robot was programmed to give the next filmstrip presentation.

Collection of the data continued for each group according to the schedule shown in Appendix I. Upon completion of the experiment, the individual module tests were graded using a computer. The module test scores were inserted into an electronic spreadsheet and summed to form individual posttest scores.

Delayed retest.--Two weeks after the completion of the experiment, a delayed retest was administered to all participants and given in rooms 301, 303, and 306 of Southeastern Oklahoma State University's Engineering Technology Building. The retest was a concatenation of the individual module tests. Before the test instrument was administered, the researcher read the instructions to the subjects. The subjects were given one hour to complete the instrument and no one was allowed to leave until all had finished. At the end of the testing period, all test were collected and graded using a computer. The results were inserted into an electronic spreadsheet for later analysis.

Methods for Analyzing Data

The data generated from the experiment was initially inserted into an electronics spreadsheet to simplify the organization of the data. The data was imported from an electronic spreadsheet into a microcomputer statistical program (6). Descriptive statistics were calculated for all groups and two-way analysis of variance and a t-test for correlated means were used to determine significance. The following research hypotheses were used as guidelines for the data analysis.

Hypothesis 1. The experimental groups will make a significant mean gain from the pretest to the posttest on a robotic technology achievement test. This hypothesis was analyzed using a t-test for correlated means. The pretest score of Group I was used as one variable and the posttest score as the other.

Hypothesis 2. The control group will make a significant mean gain from the pretest to the posttest on a robotic technology achievement test. The hypothesis was analyzed using a t-test for correlated means. The pretest score of Group II was used as one variable and the posttest score as the other.

Hypothesis 3. The experimental group will make a significantly higher mean posttest score than the control

TABLE X

ORGANIZATION OF DATA FOR ANALYSIS OF HYPOTHESIS 3

Group	Control	Experimental
Pretested	Posttest Group II	Posttest Group I
Unpretested	Posttest Group IV	Posttest Group III

group on a robotic technology achievement test. This hypothesis was analyzed using two-way analysis of variance with one variable being the treatments (experimental and control), and the other being the type of pretesting (pretested, unpretested). Table X shows the organization used to analyze the data. The dependent variable for this design was the posttest scores of the experimental groups.

Hypothesis 4. The experimental group will make a significantly higher mean delayed retest score than the control group on a robotic technology achievement test. Two-way analysis of variance was used to analyze the significance between the two means. The same design as Hypothesis 3 was used except delayed retest scores were used as the dependent variable.

Hypothesis 5. The experimental group will make significantly higher mean module scores on a robotic technology achievement test than the control group. Two-way analysis of variance was used to examine the significance between module group means.

Data collected from the study was entered into tables and graphs and discussed in Chapter IV. Hypotheses were restated in the null form and tested at the .05 level of significance.

Summary

This chapter covered the methodology used to collect and analyze the data. Volunteer subjects were solicited from the Division of Industry and randomly assigned to four groups. Groups I and II were pretested while Groups III and IV were not pretested. The experimental groups (Groups I and III) were subjected to a robot controlled sound/filmstrip presentation, while the control groups (Groups II and IV) were presented the identical sound/filmstrip by a human being. All groups were tested at the end of each module and the individual module scores were summed to obtain a posttest score. A delayed retest was given approximately two weeks after the completion of the experiment. All test information was placed into an electronic spreadsheet and submitted to a microcomputer statistical program for analysis. Chapter IV contains the analysis of the data collected in this research.

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CHAPTER IV

ANALYSIS OF DATA

This chapter contains an analysis of the data collected in the administration of a robotic technology achievement test instrument. The test instrument was administered to volunteer subjects who participated in an experiment on the effectiveness of a robot in presenting a sound/filmstrip. The data for the experiment was gathered during the 1985 fall semester at Southeastern Oklahoma State University. This chapter consists of a restatement of the research hypotheses as null hypotheses, and an analysis of the test scores acquired from the study.

Restatement of the Research Hypotheses as Null Hypotheses

The following null hypotheses were formulated to carry out the purposes of this study.

Hypothesis 1. There is no significant difference in pretest and posttest mean achievement scores of the experimental group (Group I) as measured by a robotic technology achievement test.

Hypothesis 2. There is no significant difference in pretest and posttest mean achievement scores of the control group (Group II) as measured by a robotic technology achievement test.

Hypothesis 3. There is no significant difference between the experimental and control groups' posttest mean achievement scores as measured by a robotic technology achievement test.

Hypothesis 4. There is no significant difference between the experimental and control groups' delayed retest mean achievement scores as measured by a robotic technology achievement test.

Hypothesis 5. There is no significant difference between the experimental and control module scores as measured by the module achievement tests.

Analyses of the Data

The descriptive statistics for the experiment are shown in Table XI. The pretest, posttest, and delayed retest mean scores have been plotted into the form of a histogram. (See Figure 8.) The histogram indicates: 1) the pretest scores for Groups I and II are essentially equal, 2) Group II has the highest posttest and delayed retest scores, and 3) Group III has the lowest posttest and delayed retest scores.

The raw data gathered from the administration of the test instrument was statistically analyzed using t-tests for correlated means and two-way analysis of variance. The

TABLE XI

MEAN ACHIEVEMENT SCORES ON
PRETEST, POSTTEST, AND DELAYED RETEST

GROUP	TEST	MEAN	STD. DEV.	N	STD. ERR.	RANGE
I	Pre. Post. Del. Ret.	47.10 63.95 58.14	11.45 15.75 15.82	21 21 21	2.50 3.44 3.45	24-66 31-88 20-81
II	Pre. Post. Del. Ret.	46.85 64.10 59.95	13.33 16.62 16.76	20 20 20	2.98 3.72 3.75	18-68 36-87 31-84
III	Post. Del. Ret.	57.47 53.21	17.76 18.31	19 19	4.07 4.20	36-87 23-82
IV	Post. Del. Ret.	61.21 58.46	15.46 14.92	24 24	3.15 3.05	34-83 33-78

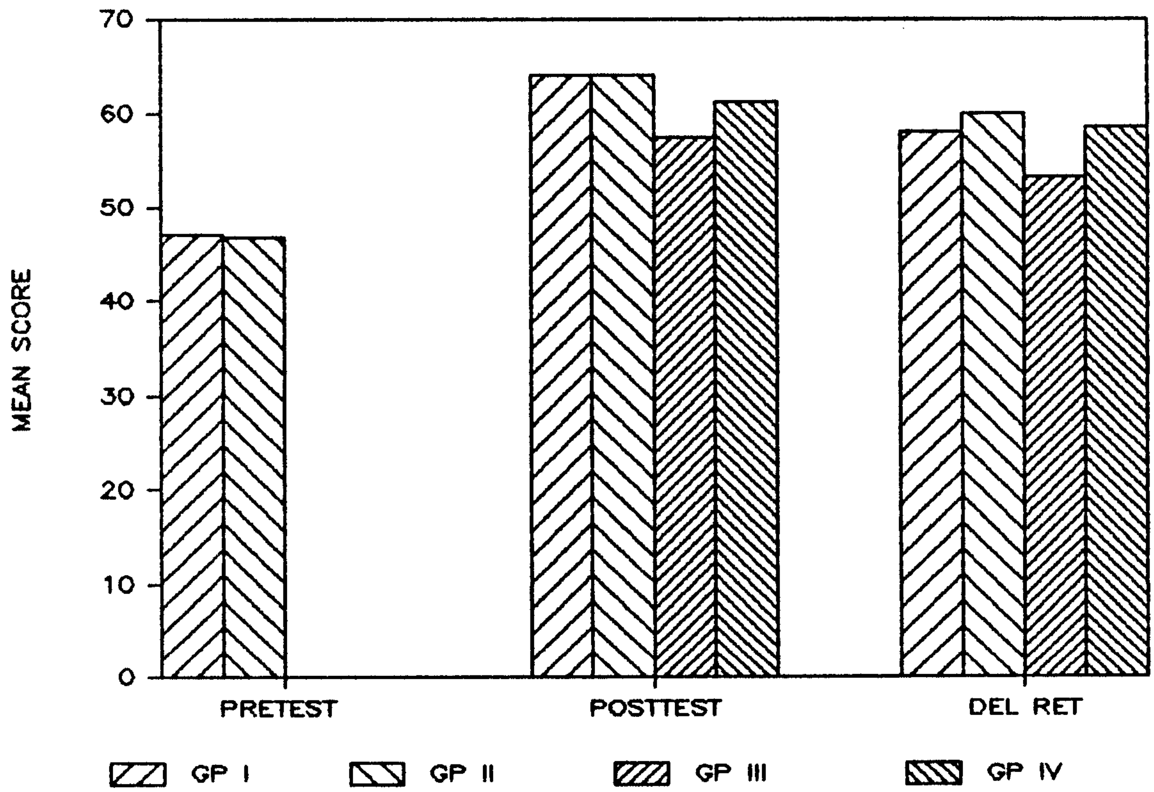

Fig 8.--Histogram of pretest, posttest, and delayed retest mean scores

analyses were performed according to the hypothesis. The following analyses were formulated:

Hypothesis 1: There is no significant difference in pretest and posttest mean achievement scores of the experimental group (Group I) as measured by a robotic technology achievement test. The pretest mean score for Group I was obtained October 24, 1985, and the posttest mean score was obtained November 11, 1985, by summing individual module test scores. Table XII presents the mean achievement scores for the pretest and posttest. The posttest mean score for Group I (63.95) was substantially higher than its pretest score (47.10).

TABLE XII

PRETEST AND POSTTEST MEAN ROBOTIC ACHIEVEMENT SCORES FOR GROUP I

	NUMBER	MEAN	STANDARD DEVIATION	STANDARD ERROR	RANGE
Pretest	21	47.10	11.45	2.49	24-66
Posttest	21	63.95	15.74	3.44	31-88

A t-test for correlated means was performed to determine the significant difference between the pretest mean score and the posttest mean score (1, p. 659). Table XIII presents the analysis of the data.

The analysis indicates a highly significant result (p=.0001) at the .05 level. The null hypothesis is

TABLE XIII

T-TEST FOR CORRELATED MEANS USING PRETEST AND POSTTEST ACHIEVEMENT SCORES OF GROUP I

t (20)= -9.75	p= 0.0001

rejected. The analysis suggests that the robot controlled sound/filmstrip was effective in imparting information on robotic technology.

Hypothesis 2: There is no significant difference in pretest and posttest mean achievement scores of the control group (Group II) as measured by a robotic technology

TABLE XIV

PRETEST AND POSTTEST MEAN ROBOTIC ACHIEVEMENT SCORES FOR GROUP II

	NUMBER	MEAN	STANDARD DEVIATION	STANDARD ERROR	RANGE
Pretest	20	46.85	13.33	2.98	18-68
Posttest	20	64.10	16.62	3.72	36-87

achievement test. The pretest score for Group II was obtained October 24, 1985, and the posttest score was obtained November 11, 1985, by summing individual module test scores. Table XIV presents the mean achievement scores for the pretest and posttest. The posttest mean score for Group II (64.10) was substantially higher than the pretest mean score (46.85).

A t-test for correlated means was performed to determine the significant difference between the pretest mean score and the posttest mean score (1, p. 659). Table XV presents the analysis of the data.

TABLE XV

T-TEST FOR CORRELATED MEANS USING PRETEST AND POSTTEST ACHIEVEMENT SCORES OF GROUP II

t= -8.99	p= 0.0001

The analysis indicates a highly significant result (p=.0001) at the .05 level. The null hypothesis is rejected. The analysis suggests that the human being controlled sound/filmstrip presentation was effective in imparting information on robotic technology.

TABLE XVI

GROUP POSTTEST MEANS AND STANDARD DEVIATIONS

GROUP	MEAN	STANDARD DEVIATION	N
I	63.95	15.75	21
II	64.10	16.62	20
III	57.47	17.76	19
IV	61.20	15.46	24

Hypothesis 3. There is no significant difference between the experimental and control groups' posttest mean

achievement scores as measured by a robotic technology achievement test. This analysis required the posttest scores for all groups. Table XVI shows the group posttest means and standard deviations.

A 2 x 2 analysis of variance design was used to organize the means for analysis (2, pp. 24-26). Table XVII shows this design.

TABLE XVII

2 x 2 ANALYSIS OF VARIANCE DESIGN FOR HYPOTHESIS 3

Group	Control	Experimental
Pretested	Group II (64.10)	Group I (63.95)
Unpretested	Group IV (61.20)	Group III (57.47)

Groups II and IV means were compared with Groups I and III means to determine the effectiveness of the experimental treatment. Groups I and II means were compared with Groups III and IV means to determine the effects of pretesting. Two-way analysis of variance was used to analyze the various effects. Table XVIII depicts the results of the analysis.

Table XVIII indicates no significant difference (p=.60) between the control and experimental groups' mean achievement scores at the .05 level. The null hypothesis is retained. Groups I and III (experimental) mean achievement scores were not significantly different from Groups II and IV (control) mean achievement scores.

TABLE XVIII

TWO-WAY ANALYSIS OF VARIANCE FOR
POSTTEST MEAN SCORES

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	VARIANCE ESTIMATE	F	p
Treatment	78.53	1	78.53	.29	0.60
Pretest	457.51	1	457.51	1.71	.19
Interaction	67.04	1	67.04	.25	.62
Within	21375.45	80	267.19		

The table also indicates that the pretest had no significant effect (p=.19) on the posttest scores and interaction between pretest and treatment was insignificant (p=.62). These results agree with the findings of Welch and Walberg (3).

TABLE XIX

GROUP DELAYED RETEST MEANS
AND STANDARD DEVIATIONS

GROUP	MEAN	STANDARD DEVIATION	N
I	58.14	15.82	21
II	59.95	16.76	20
III	53.21	18.30	19
IV	58.46	14.92	24

Hypothesis 4. There is no significant difference between the experimental and control groups' delayed retest means as measured by a robotic technology achievement test. This analysis required the delayed retest scores for all groups. Table XIX shows the means and standard deviations for all group delayed retest scores.

A 2 x 2 analysis of variance design was used to organize the means for analysis. Table XX shows this design.

TABLE XX

2 x 2 ANALYSIS OF VARIANCE DESIGN FOR HYPOTHESIS 4

Group	Control	Experimental
Pretested	Group II (59.95)	Group I (58.14)
Unpretested	Group IV (58.46)	Group III (53.21)

Groups II and IV means were compared with Groups I and III means to determine the effectiveness of the experimental treatment. Groups I and II means were compared with Groups III and IV means to determine the effects of pretesting. Two-way analysis of variance was used to determine the various effects. Table XXI depicts the results of the analysis.

Table XXI indicates no significant difference (p=.33) between the control and experimental groups' mean achievement scores at the .05 level. The null hypothesis is retained. Groups I and III (experimental) mean achievement scores were not significantly different from Groups II and IV (control) mean achievement scores. This indicates the information retained by the experimental and control groups was essentially the same over time.

TABLE XXI

TWO-WAY ANALYSIS OF VARIANCE FOR DELAYED RETEST MEAN SCORES

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	VARIANCE ESTIMATE	F	p
Treatment	259.34	1	259.34	.97	0.33
Pretest	215.03	1	215.03	.80	.37
Interaction	61.68	1	61.68	.23	.64
Within	21498.64	80	268.73		

The table also indicates the pretest had no significant effect (p=.37) on the posttest scores and interaction between pretest and treatment was insignificant (p=.64) at the .05 level. This agrees with the findings of Hypothesis 3.

Hypothesis 5. There is no significant difference between the experimental and control module scores as measured by the module achievement tests. The primary purpose of this hypothesis is to determine the effectiveness of the experimental treatment over the experimental time period.

TABLE XXII

DESCRIPTIVE STATISTICS DAILY MODULE TESTS

Group	Module	Mean	Std. Dev.	N	Std. Err.	Range
I	1	12.57	3.11	21	.68	3-16
	2	10.38	2.20	21	.48	6-14
	3	10.43	2.93	21	.64	5-14
	4	11.10	3.02	21	.66	6-15
	5	10.62	3.37	21	.74	4-15
	6	8.86	3.81	21	.83	3-15
II	1	13.20	2.50	20	.56	8-16
	2	10.25	2.61	20	.58	4-14
	3	10.05	3.05	20	.68	5-15
	4	11.15	2.91	20	.65	6-16
	5	9.90	4.47	20	1.00	2-16
	6	9.55	3.43	20	.77	4-15
III	1	12.26	3.28	19	.75	6-16
	2	9.74	3.03	19	.70	4-14
	3	9.42	3.25	19	.75	4-15
	4	9.89	3.75	19	.86	4-16
	5	8.68	3.67	19	.84	3-14
	6	7.47	3.96	19	.91	3-15
IV	1	13.13	2.11	24	.43	8-16
	2	9.58	2.69	24	.55	3-14
	3	10.33	2.93	24	.60	6-15
	4	10.29	3.48	24	.71	5-16
	5	9.00	4.04	24	.83	1-15
	6	8.88	2.64	24	.54	4-12

The descriptive statistics for the daily module tests are given in Table XXII. The means presented in the table were plotted into line graphs and the results are shown in Figure 9. The graph shows that all groups scored highest on Module 1 and lowest on Module 6. The graph suggests a downward trend in mean achievement scores for both the experimental and control groups.

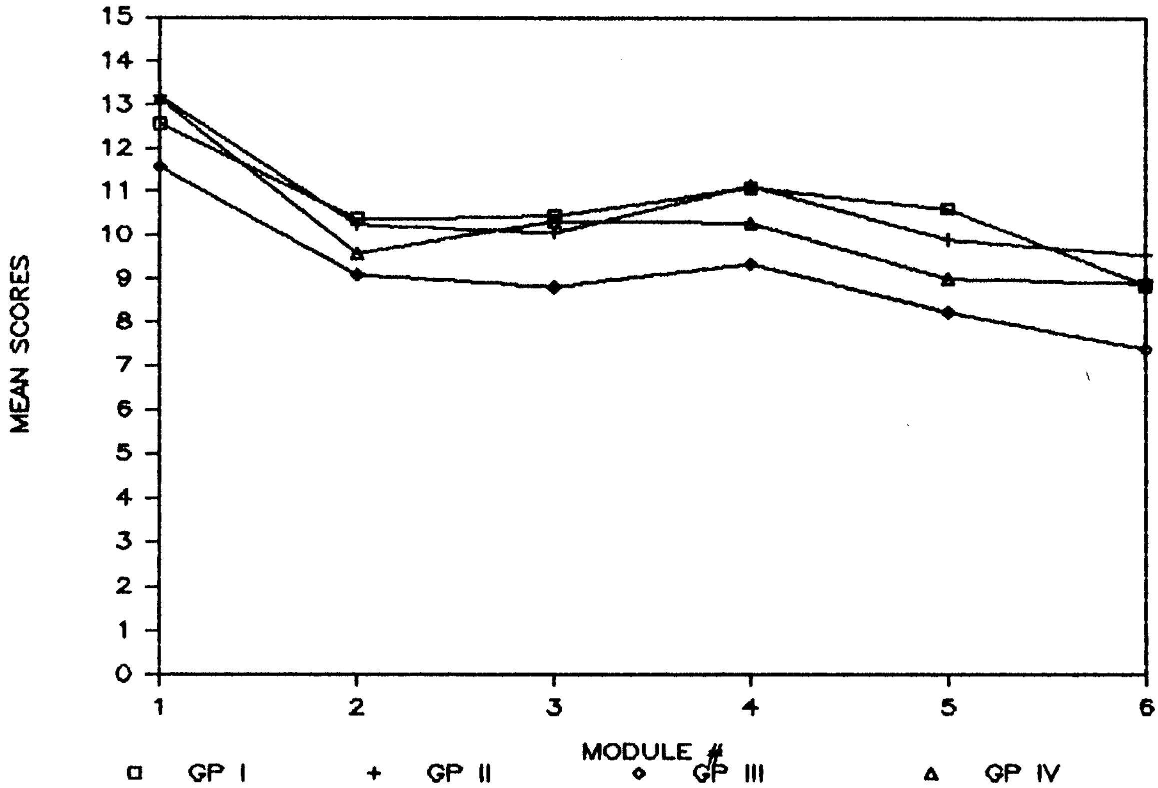

Fig 9.--Daily module means for all groups

The experiment was conducted for a period of six days. Upon the completion of a daily treatment, each group was administered a sixteen question module test. To determine the effectiveness of the experimental treatment over the six day period, a two-way analysis of variance was performed using the daily module test scores. The module mean scores were combined with the corresponding treatment, pretest, and interaction F-ratio and plotted into a series of line graphs. The line graphs give an indication of trends that occurred over the six day experimental period.

TABLE XXIII

MODEL USED TO ANALYZE HYPOTHESIS 5

Group	Control	Experimental
Pretested	Group II Module Means	Group I Module Means
Unpretested	Group IV Module Means	Group III Module Means

A 2 x 2 analysis of variance model was used to organize the module data. (See Table XXIII.) The F-ratios for the module are given in Table XXIV.

TABLE XXIV

MODULE F-RATIOS FOR HYPOTHESIS 5

	MODULE					
Variation	1	2	3	4	5	6
Treatment	1.52	.60	.16	.10	.06	1.91
Pretest	.10	1.28	.30	2.02	2.74	1.85
Interaction	.40	.06	.99	.06	.36	.22

To determine trends in the main effect, Groups I and III raw scores were combined to form an experimental group mean and Groups II and IV raw scores were combined to form a control group mean. This was done for all modules so that six means were obtained for the experimental groups and six means were obtained for the control groups. The means were plotted to form a graph that shows the relationship among the experimental means, control means, and treatment F-ratio. This graph is shown in Figure 10.

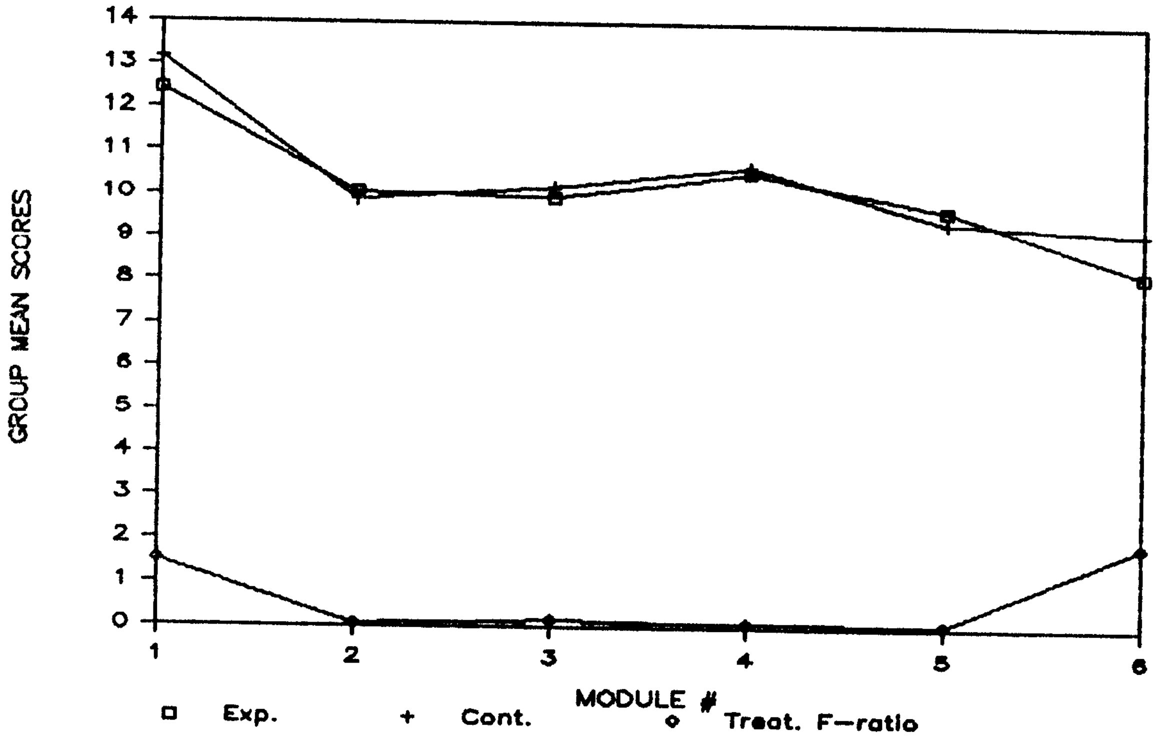

Fig. 10.--Experimental means, control means, and treatment F-ratio

The graph indicates that the largest difference in means occurred for Module 1 and Module 6, while Modules 2 through 5 essentially showed no difference. The differences can clearly be seen by observing the distance between means and the F ratio for a given module. There does not seem to be a discernible trend in differences between group means.

To determine trends in pretesting effects, Groups I and II raw scores were combined to form a module mean, and Groups III and IV raw scores were combined to form a module mean. The combined means for all modules were plotted with their pretest F-ratio. The resulting graph is shown in Figure 11. The graph essentially indicates no pretesting

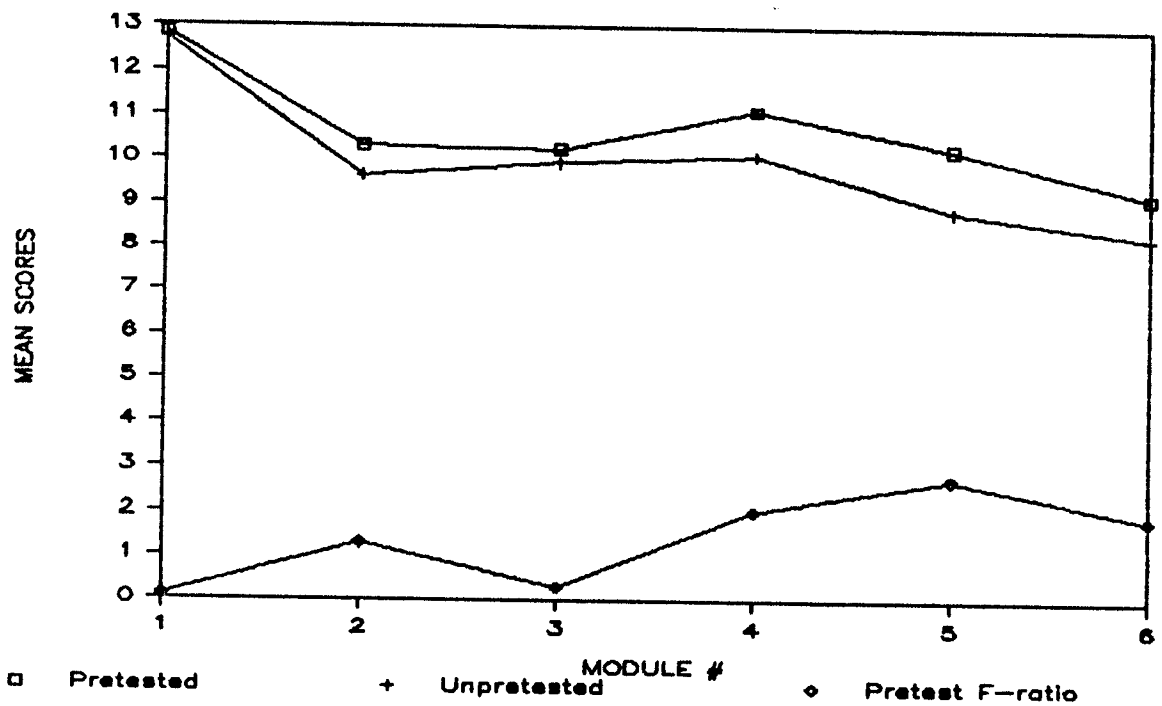

Fig. 11--Pretest, unpretested, and pretest F-ratio

effects for Module 1; but, for Modules 3, 4, and 5 there is an increasing difference between means. Also the difference between Groups I and II means was consistently higher than Groups III and IV means. As the subjects progressed through the experiment, it appears that Groups I and II learned more from the previous module or modules than Groups III and IV.

This difference is probably not due to the pretest taken prior to the execution of the experiment.

To determine trends in pretest interaction, module means for all groups were plotted with the corresponding interaction F-ratio. The resulting graph is shown in Figure 12. The interaction effect was insignificant for all

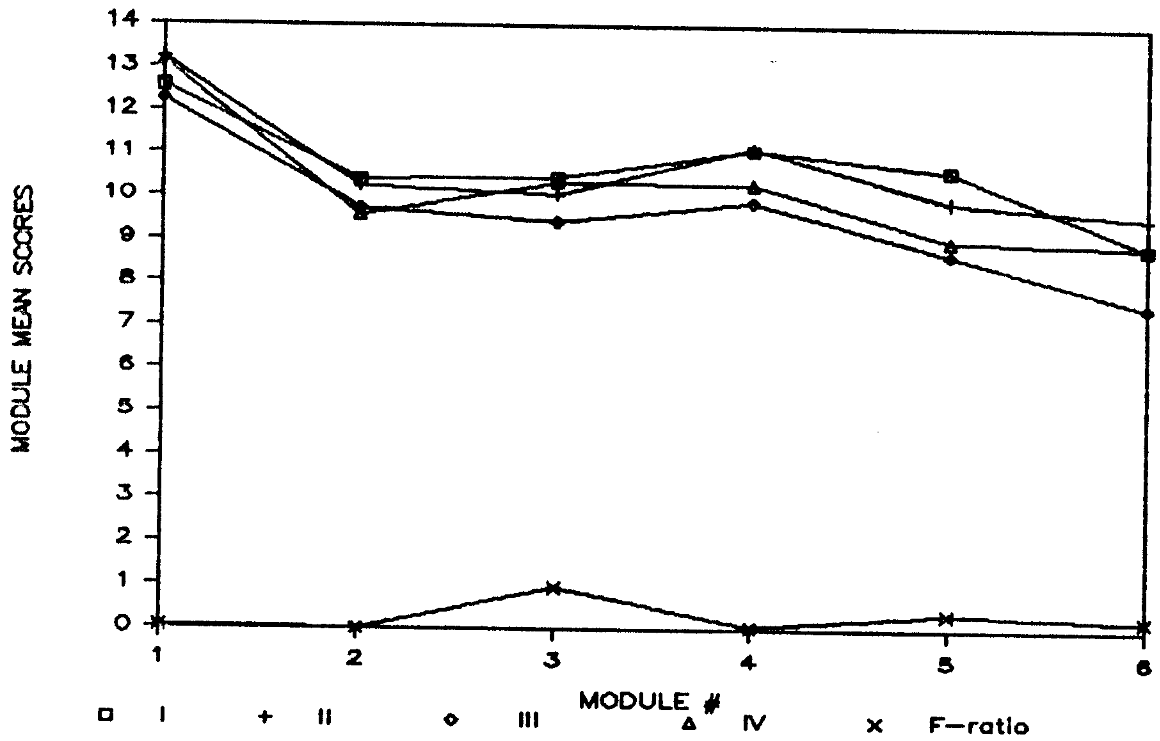

Fig 12.--Module means vs. interaction F-ratio

modules and no trends in interaction could be extrapolated from the graph. The largest interaction occurred for Module 3 means. This interaction is indicated by an F ratio greater than 1.00 and a crossover of three module means.

All module analyses indicated no significant difference in the type of treatment at the .05 level. The null hypothesis is retained. Pretesting and interaction effects were also insignificant at the .05 level. The module results agree with the overall results obtained from Hypotheses 3.

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CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This chapter presents a brief review of the purposes and design of the study. The findings are stated, conclusions are drawn, and recommendations are given.

Background

Since early times men have dreamed of having "mechanical slaves" that could perform tedious, undesirable, or dangerous tasks. Within the last ten years, "mechanical slaves" called robots have appeared that have taken over some of the more undesirable industrial work. The robot is rapidly replacing workers in a number of industries so that many of the present day manufacturing jobs will be lost by the end of this decade.

The types of jobs that will be lost will be primarily those that are unskilled, unsafe or undesirable. The robot can work in environments where humans cannot and the robot can work for indefinite periods of time without rest or breaks. Typical types of work that would be candidates for robotization would be arc welding and spray painting. Even though the robot will replace workers in certain jobs, robots themselves will create new types of work.

The types of work the the robot will create will primarily be skilled in nature. The reason for this is the way robots are constructed. Robots are essentially electro-mechanical devices that are controlled by a computer. Robots will need skilled mechanics and electronic technicians to maintain them as well as computer programmers to make them perform properly. The skilled personnel required for a modern robotics based manufacturing facility will be primarily trained in vocational-technical schools, community colleges, and four-year colleges and universities.

The institutions saddled with the responsibility for training people in the area of robotics will have to decide upon a training approach. One of the limiting factors in this approach is the type of robot the school has access to. If the school has access to an industrial manipulator, it would probably be more interested in teaching robotic engineering and industrial applications. However, if the school has access to a personal robot trainer, it may be more interested in teaching robot maintenance and programming.

The robot trainer has many unique features that allow it to be used extensively for teaching robotic technology. Most robotic trainers are microcomputer controlled, have onboard speech synthesizers, and ultrasonic ranging detectors. The cost for these trainers has declined substantially in the last few years so that it is now possible for most technical programs to purchase at least one.

The institutions that purchase one of these robots may only use it for certain classes during a given school year. There may be relatively long periods of time when the robot is not being used for teaching robotic technology. During these lax periods, the robot could be put to other uses such as security duties, recruiting, or showing a sound/filmstrip.

Purposes of the Study

The purposes of this study were:

1. To determine the effects a robot controlled filmstrip projection has on achievement.

2. To determine the effects a human controlled filmstrip projection has on achievement.

3. To compare the effectiveness of a personal robot in presenting a sound/filmstrip on robotic technology to a human being presenting a sound/filmstrip on robotic technology.

To achieve the purposes, the student sample was divided into two control groups and two experimental groups. The effectiveness of the experimental variable was determined by administering two of the groups a pretest, and all four groups a posttest, and a delayed retest.

To accomplish the purposes of this study the following research hypotheses were formulated:

1. The experimental group will make a significant mean gain from the pretest to the posttest on a robotic technology achievement test.

2. The control group will make a significant mean gain from the pretest to the posttest on a robotic technology achievement test.

3. The experimental group will make a significantly higher mean posttest score than the control group on a robotic technology achievement test.

4. The experimental group will make a significantly higher mean delayed retest score than the control group on a robotic technology achievement test.

5. The experimental group will make significantly higher mean module scores on a robotic technology achievement test than the control group.

Review of the Literature

The review of the literature in Chapter II contained relevant information on industrial robots, personal robots, robots in education, instructional media, and the effects of pretesting. These sections were included because an understanding of this information was important for the proper execution of the experiment.

The review on industrial robots revealed they are essentially replicas of the human arm and hand. This replica, called a manipulator, is usually controlled by a computer and allows the robot to perform such functions as arc welding and spray painting. The level of sophistication for robots is increasing with the development and applications of new technology. The high technology robots will perform more complicated operations and have a substantial impact on industrial productivity.

Personal robots are primarily used by hobbyists and educators. The personal robot is classified as a turtle, arm, or mobile robot.

Turtles are small, circular, wheeled robots that are connected to a microcomputer with a cable. The primary function of the turtle is to teach programming and geometric concepts to primary school children. The mechanical turtle has been replaced in many instances with the graphics turtle. Arms are miniature replicas of the industrial robot and are primarily used by educators as a teaching aid for robotic technology. Mobile robots on the other hand, are anthropomorphic in nature and have on-board microcomputers to control their movements. Like the arm, the mobile robot is used by many educational institutions as a teaching aid.

Robots have been used in education primarily as a teaching aid for computer programming and mathematics. Robots are used to teach programming because they allow the student to observe the effects of the program on the movement of the robot. The mobile robot is especially useful for teaching geometry because the student has to understand a geometric pattern before the robot can be programmed. The uses of robots in education have been primarily limited to teaching grade school students on an individualized or small group basis.

The literature on robots in education indicated that no research has been performed on the uses of robots as teachers. The primary reason for this is that most educators do not know the capabilities of modern robots. Robots are presently being manufactured that have the abilities to move very precisely, generate and recognize human speech, and control the external environment. With these capabilities there seems to be no reason why robots cannot perform certain teaching functions such as showing a sound/filmstrip to a group of students.

A sound/filmstrip is a type of still instructional media. There has been substantial research on the effectiveness of instructional media with most researchers concluding that it is at least as effective as traditional methods.

To determine the effectiveness of instructional media, many researchers perform a comparison type study. Comparison studies quite frequently employ a pretest to determine a subject's knowledge level. The research indicates that pretesting could jeopardize results and should be taken into account when performing an experiment.

Findings

Using the hypotheses as guidelines, the following were the findings of this study.

1. The subjects that were shown the filmstrip by the robot learned from the filmstrip. The pretested experimental group's mean posttest score was significantly higher than its pretest mean score. The research hypothesis is accepted.

2. The subjects that were shown the filmstrip by the human being learned from the filmstrip. The pretested control group's mean posttest score was significantly higher than its pretest mean score. The research hypothesis is accepted.

3. The experimental groups (Groups I and III) did not achieve significantly higher mean scores on a posttest than the control groups (Groups II and IV). The research hypothesis is rejected.

4. The experimental groups (Groups I and III) did not achieve significantly higher mean scores on a delayed retest than the control groups (Groups II and IV). The research hypothesis is rejected.

5. The experimental groups (Groups I and III) did not achieve significantly higher mean module scores than the control groups (Groups II and IV). The research hypothesis is rejected.

Conclusions

Using the findings of this study, the following conclusions were drawn.

1. Students learn from a sound/filmstrip whether it is presented by a human being or by a robot.

2. A robot is a viable alternative to the human teacher in certain situations. The robot can replace the teacher in situations where the student-teacher interaction is limited. The robot in this experiment could not answer questions from the students nor could it repeat portions of the filmstrip. A teacher on the other hand could easily answer questions pertinent to the filmstrip as well as repeat sections of the filmstrip that were not clear to the student. This ability could have significant effects on student achievement.

Recommendations

1. Robots should be used as replacements for teachers only in situations where there is a minimum of student/teacher interaction.

2. The time duration of instructional media presented by a robot should be kept to a minimum, typically, no more than twenty minutes.

3. The robot should not be used over long periods of time as a teacher replacement. In a given semester, for example, the robot might be used twice to present a filmstrip.

4. This study should be replicated using a more sophisticated robot. A robot that has a limited ability to answer questions and repeat certain portions of the filmstrip might be more effective in its presentation.

5. The study should be replicated using subjects of a different age group. The subjects used for this experiment were college freshmen, sophomores, juniors, and seniors. The experiment may have produced more significant results if grade school subjects were used because the literature indicates that personal robots have been used as a successful teaching tool for younger students.

6. A similar study should be conducted to determine the effects a robot has on attitudes towards different subjects. For example, it may be interesting to find out if a robot would have a more positive effect on attitudes towards robots than human beings.

7. A study should be conducted that tests the effectiveness of robots as an individualized teaching tool.

APPENDICES

APPENDIX A

LIBRARY FILMSTRIP CENTER
608 East Locust • Bloomington, Illinois 61701 • Ph. (309) 827-5455

June 13, 1985

Doug Keenan
Southeastern Oklahoma State University
Box 4191
Durant, OK 74701

Dear Mr. Keenan:

Thank you for your interest in our Robotics filmstrip series. I am glad to hear that you have been impressed with the content.

We hereby grant you permission to reproduce the audio track in the following manner:

1. You may make one copy of each cassette as an archive "backup" in case of damage to the original tapes.
2. You may program the narrative portions into your personal robot as described in our telephone conversation for use in your doctoral dissertation, and presentation to your students.

Any other reproductions, or alterations, of these materials should be cleared with this office prior to production.

Your robot sounds like a very interesting project, and one that might have some promotional use for us in the future. Is it possible that we may be able to borrow the robot for demonstration at an educational convention? How large is the robot? What type of power system does it require?

I will look forward to hearing from you. Best wishes with your dissertation.

Sincerely,

JoAnn Amore
Marketing Manager

JA:cl

APPENDIX B

ROBOT AND COMMAND SYSTEM DESCRIPTION

The robot and command system were designed and built by the researcher at Southeastern Oklahoma State University. The time required to complete the robot was more than one year while the command system was designed approximately one month prior to the execution of the experiment.

The Robot

The robot was composed of three major sections: 1) a body, 2) a microcomputer controlled mobile platform, and 3) two interfacing circuits. The body was designed and fabricated by a local electronics firm while the platform and interfacing circuits were built by the researcher. Since the mobile platform was microcomputer controlled, it was necessary to write two programs that would cause the robot to perform its duties correctly.

Body.--The plastic body was fabricated by the modeling department at the Texas Instrument's Sherman plant. The robot measured 51 inches in height from the base to the top of it's head and 15 inches across the front of the chest. Figure 13 shows the front and side view of the robot. The body was constructed of a lightweight modeling plastic that imparted both strength and rigidity to the robot. The body consisted of two separate units, a torso and a head. The torso had two immovable arms attached to it while the head had two blinking green lights for eyes and two plastic bars for ears.

When the robot body was initially received from the manufacturer the head had no external features. In order to complete the head, "eyes", "ears", and a "mouth" had to be installed.

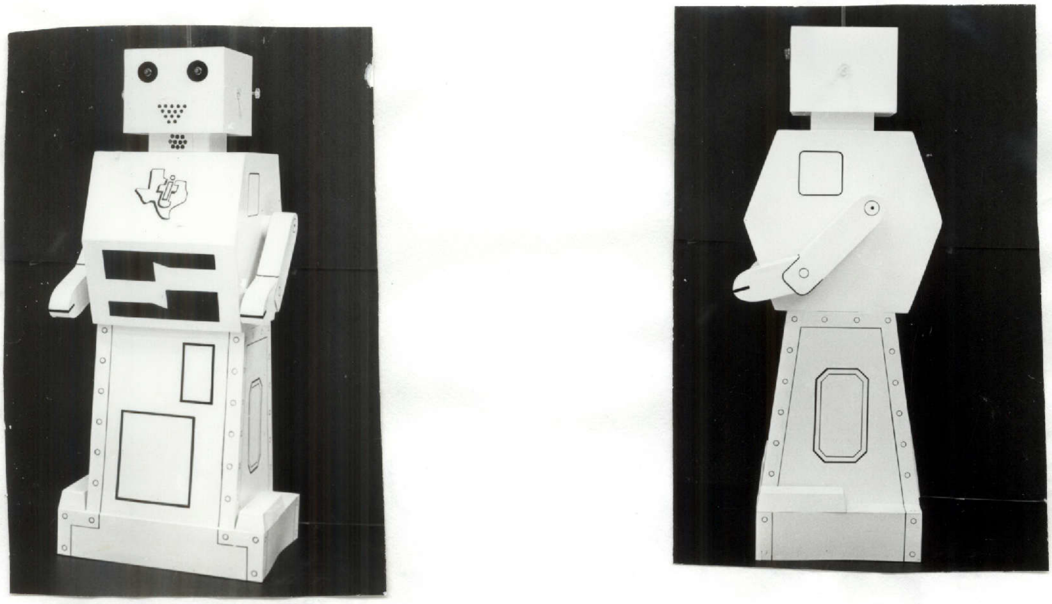


Fig. 13.--Robot body

The eyes were constructed by using two 6 volt incandescent lamps while each ear was made of a clear plastic bar with a green light emitting diode (LED) glued into one end. A battery powered electronic circuit was designed that caused the eyes to blink alternately with one another and the ears to blink in sequence with opposite eyes. A plastic bar was glued to the top of the robot's head to give it a more robotic "look." The bar had a red LED glued into one end that blinked at half the rate of the eyes.

The mouth was formed from fourteen red LEDs arranged in a "Y" configuration. The top row of the mouth contained five LEDs, of which, the center three were lit continuously. A circuit was designed that caused the other eleven LEDs to blink in sequence with an audio signal. This gave the robot's mouth the appearance of talking when the onboard cassette recorder was playing a tape.

The head and torso were separate units so the head could be removed for transportation purposes, modifications, and maintenance. The circuitry for the mouth was mounted in the head next to the eye and ear circuitry. Wires for power and the audio signal ran from the platform through the torso and neck, to the circuits in the head. The audio signal that powered the mouth circuitry also drove a small speaker mounted in the neck.

The lower body torso had a rectangular mounting fixture that precisely fit the mobile platform. The mounting fixture had screws and fittings so the body could be firmly attached to the platform. The lower backside of the torso had a sliding door so that the platform controls and cassette recorder could be easily reached.

<u>Microcomputer controlled mobile platform</u>.--The microcomputer controlled mobile platform was fabricated from aluminum sheet metal in the form of a 15" x 15" x 3" rectangular box. Figure 14 shows a front and side view of the platform. The top of the platform had openings cut into it so that cables and wires could be brought out to the cassette recorder and head circuitry. It was also removable so that access could be obtained to the internal electronics. The platform had two front wheels (each driven by a separate motor) and two casters for rear wheels. Driving the wheels with separate motors allowed the platform to turn on its center axis.

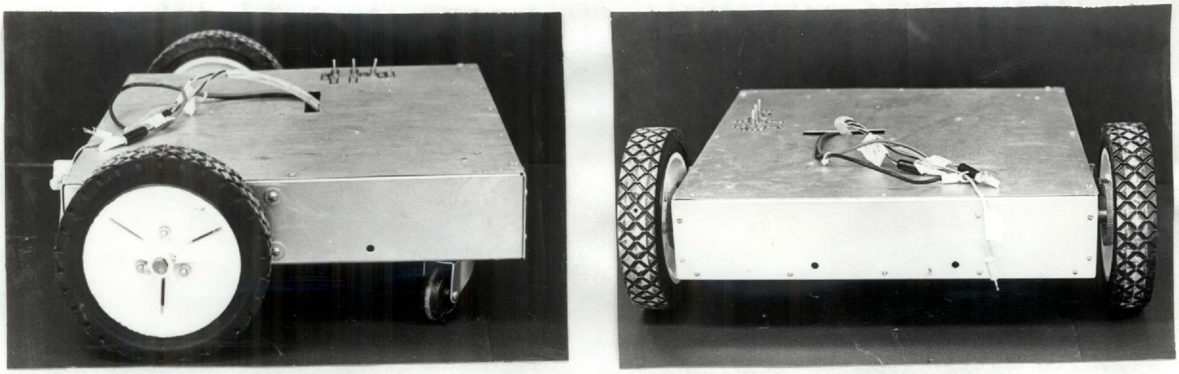


Fig. 14--Microcomputer controlled mobile platform

The motors used to drive the front wheels were of a special type called stepping motors. (See Figure 15.) A stepping motor has the ability to rotate a certain number of degrees when a sequence of electrical pulses is applied to it. The motors used in the platform would turn 1.8 degrees for each pulse sequence. The stepping motors were mounted internally and were coupled to the wheels through an

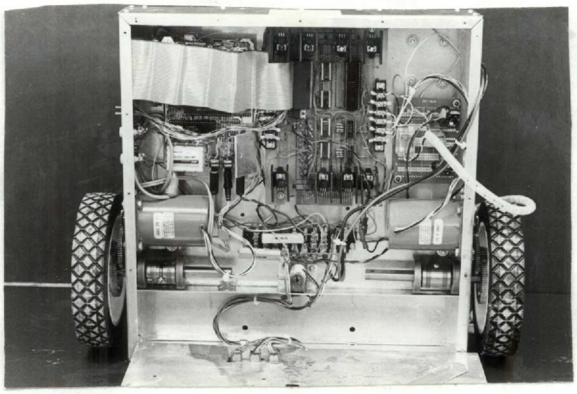


Fig. 15--Internal electronics of platform

8.66:1 stepdown gear ratio. The stepdown gear ratio would cause the wheels to rotate .208 degrees for each pulse sequence applied to the motors. Since the diameter of the wheels were known, the number of pulses required to drive the robot a precise distance could be easily calculated. The distance calculations were done by a microcomputer mounted inside the mobile platform.

The microcomputer used to control the platform was a modified Z-80 microprocessor based Timex/Sinclair. (See Figure 15.) The Timex/Sinclair was originally designed as an inexpensive home computer that consisted of a single printed circuit board and a plastic case with a membrane keyboard embedded into it. In order to mount the microcomputer inside the platform, it was necessary to remove the case and replace the it with an external keyboard.

The Timex/Sinclair had several accessories that were required to make its operation more efficient. Cassette ports were incorporated into the microcomputer that allowed it to load and save programs. The cassette ports were brought out from the microcomputer to the side of the platform so programs could be loaded and saved using an external cassette recorder. A memory expansion unit was connected to the microcomputer so that total memory was increased from two kilobytes to sixteen kilobytes. The expansion unit was modified so that it would not interfere with the top of the platform.

The microcomputer and motors received their power from a 12 volt lead-acid motorcycle battery. The battery was mounted in a plastic container, set on top of the platform, and connected to an internal supply bus with two 14 gauge stranded wires. A three position switch mounted in the platform top was used to change the supply bus voltage between an external source and the battery. The third switch position allowed the battery to be charged from an external source. Two other switches were used to control the power to the stepping motors.

Besides the microcomputer, the platform contained a motor and cassette interfacing circuit each of which was mounted inside the platform on individual prototyping boards. (See Figure 15.) The motor interfacing circuit let the microcomputer drive the stepping motors while the cassette interface let the microcomputer manage the recorder's remote input.

The cassette used to present the audio portion of the filmstrip was a Radio Shack CTR-80. The cassette was modified by removing the speaker and connecting two wires to the vacant terminals. The wires were routed to the robot's neck and head where they were attached to the throat mounted speaker and mouth control circuitry. This modification was performed to improve the clarity of the robot's speech.

During the filmstrip presentation, the recorder was set on the top surface of the platform so it could be easily reached. Before each module, the appropriate tape was inserted into the recorder and the play button was depressed. The cassette recorder would not play because a relay on the cassette interface board would keep the cassette's remote control in an off condition. When the robot was activated it would follow a preprogrammed path to the front of the classroom. Once the presentation began, the microcomputer would send a signal to the cassette interface board which would cause the relay to be activated and allow the recorder to play the filmstrip audiotape.

The audiotapes used by the robot were copies of the manufacturer's originals. To make the presentation more realistic, information was added to the beginning and end of the tape by a professional announcer. The recorded information had a slight echo added to it so it would sound more "robotic."

Interfacing electronics.--A block diagram of the interfacing electronics is shown in Figure 16. From the

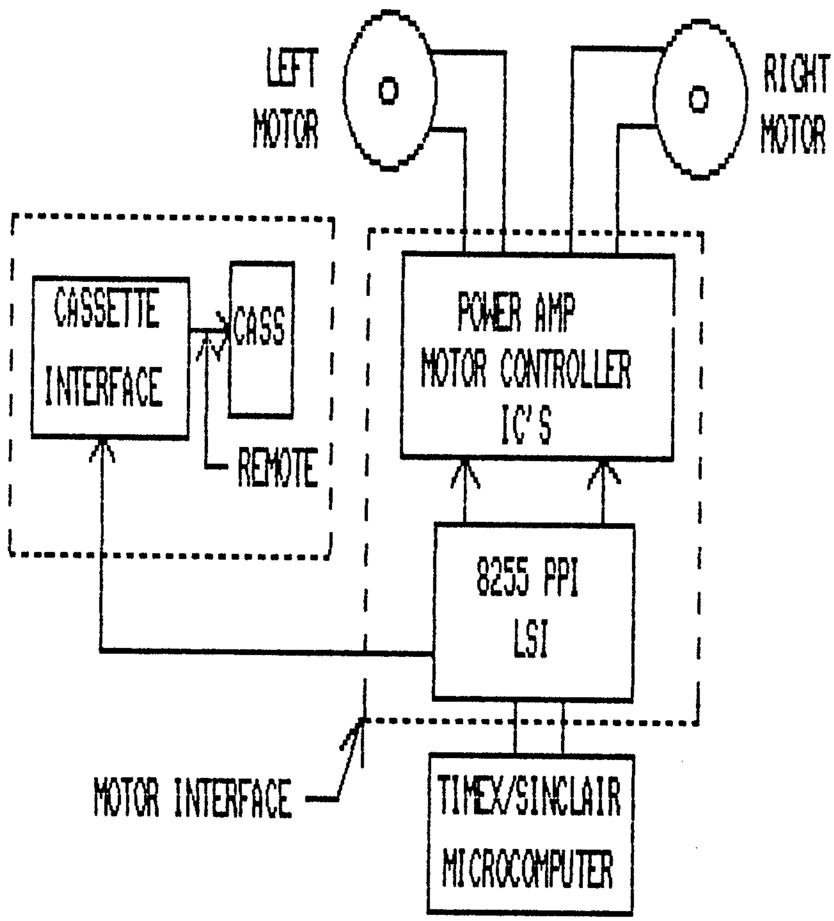


Fig. 16--Block diagram of interfacing electronics

diagram it can seen that the interfacing electronics for the robot consisted of two major circuits: 1) the motor interface, and 2) the cassette interface.

The motor interface was constructed of three main components: 1) an interfacing large scale integrated circuit (LSI), 2) a stepping motor controller, and 3) a power amplifier. The LSI was attached to the microcomputer through a group of wires called a bus. Signals were generated by the microcomputer and sent to the LSI over the bus for initialization, decoding, and control purposes. The LSI linked the microcomputer to the stepping motors IC's and cassette interface.

The LSI used in the motor interface was an INTEL 8255 programmable peripheral interface (PPI). The PPI had three programmable ports (labeled A, B, and C) that were attached to the motor drivers and cassette interface. All ports were initialized as output ports by a BASIC program written by the researcher.

The PPI ports A and B were connected to the two stepping motor IC's which provided the correct forward and reverse pulse sequence for the motors. To make a motor go forward for example, electrical signals were sent from the microcomputer to the PPI which then latched the signals to the stepping motor IC's. The IC's would convert those signals to a four pulse sequence that would cause the motor to rotate forward.

The outputs of the motor IC's were fed into eight power transistors (four per motor) which provided the current amplification necessary to spin the motors. The tranistors were heat-sinked to minimize heating effects.

Microcomputer programs.--Two microcomputer programs were written that performed all the logic required to drive the stepping motors and cassette interface. The major purposes of the programs were to: 1) initialize the PPI, 2) provide the input commands for controlling the robot, 3) provide the commands for the cassette recorder, and 4) calculate and generate the electrical pulses necessary to drive the stepping motor IC's.

To achieve the major purposes, the two programs were were written in different programming languages. Z-80 machine language was used to generate the electrical pulses while BASIC was used to initialize the PPI, provide the input commands, and calculate the number of pulses required to go a specific distance. The BASIC program passed the speed and distance parameters to the machine language program whenever electrical pulses were sent to the stepping motors. Machine language was necessary because BASIC could not produce the electronic pulses quickly enough. The machine language and BASIC listings are given at the end of Appendix B.

The two programs were loaded into the Timex/Sinclair microcomputer using a cassette recorder. The machine language program was inserted in a BASIC REM statement and then transferred into high memory using a POKE statement. Following the machine language program, the BASIC control program was loaded and executed. After execution, the program would allow the insertion of commands that would cause the robot to perform specific actions. For example, the command FD101002 would cause the robot to move forward 10 feet, 10.02 inches. Other commands were available that allowed the robot to move in a reverse direction (RV), turn right or left an exact number of degrees (RR or RL), wait a specific time period (WT), turn the cassette recorder on (PU), turn the cassette recorder off (PD), stop (ST), or execute the commands (Q).

After a number of commands were inserted into memory by the BASIC program, they were saved on cassette tape for later use. Saving the commands eliminated the need to hand program the robot for each filmstrip presentation. Table XXV shows the commands required to execute module 1. The commands for the other five modules were identical except different wait time commands (WT) were used.

Command System

The major purpose of the command system was to reduce the need for human interference during the robot presentation. The command system allowed the robot to remotely control the lights and projector.

TABLE XXV

ROBOT COMMANDS REQUIRED FOR MODULE 1

	Command	Remarks
1.	PD	Turn cassette off
2.	WT1	Wait 30 seconds
3.	FD100000	Forward 10 feet
4.	RR090	Turn right 90 degrees
5.	FD250000	Forward 25 feet
6.	RL090	Turn left 90 degrees
7.	FD060000	Forward 6 feet
8.	RL090	Turn left 90 degrees
9.	FD010000	Forward 1 foot
10.	RR045	Turn right 45 degrees
11.	PU	Turn cassette on
12.	WT7	
13.	WT6	Wait 28 minutes for
14.	WT2	the cassette audio
15.	WT6	to finish
16.	WT3	
17.	PD	Turn the cassette off
18.	RL045	
19.	RV010000	
20.	RL090	Return to the starting
21.	FD060000	position
22.	RR090	
23.	FD250000	
24.	RR180	
25.	ST	Stop

The Radio Shack TRS-80 Model III microcomputer was the central control unit for the system. (See Figure 17.) The microcomputer would analyze audio signals of various frequencies emitted by the robot and convert them into specific actions. A 1 kHz (projector advance) and 4.5 kHz (projector on/off) signal was used to control the filmstrip projector while a 1.5 kHz signal was used to activate the lights. These frequencies were recorded at specific points on the filmstrip tapes prior to the execution of the experiment.

Fig. 17--Radio Shack Model III microcomputer

Figure 18 shows a block diagram of the command system. Signals generated by the robot would be picked by the microphone and fed into an audio amplifier. The output of the audio amplifier would then be applied to the interface circuit which would detect the various frequencies. The frequencies would subsequently be analyzed by the microcomputer program (see listing at the end of the Appendix B) to determine what action should be taken. After the appropriate action was determined, the microcomputer would send a signal back to the interface circuit which would then send the appropriate response to the projector or lights.

The command system worked well as long as the signals emitted by the robot were of a constant level and frequency. On occasions, however, the signal would fluctuate and cause

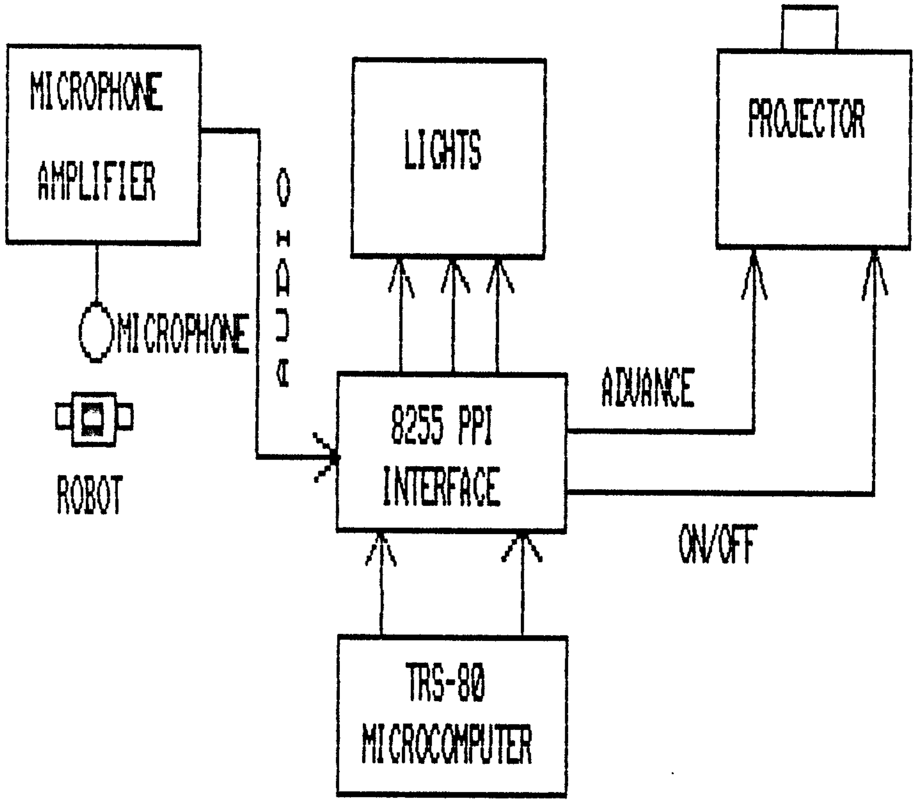


Fig. 18--Block diagram of command system

the control circuit not to perform properly. For example, a distorted advance signal might cause the projector not to move to the next frame. To eliminate this problem, the software was designed to allow an operator to override the commands from the robot. During the experiment, the operator (researcher) could observe the filmstrip from a hidden location and correct the mistakes as they occured.

The robot and command system were programmed by the researcher before each module presentation. To ensure that both were programmed properly, checklists were written that contained the procedures for correctly setting them up. The checklists are given at the end of Appendix B.

Z-80 ASSEMBLY (MACHINE) LANGUAGE PROGRAM USED TO DRIVE ROBOT

```
100          PUSH    AF         ;PUSH ALL REGISTERS
110          PUSH    DE
120          PUSH    HL
130          PUSH    BC
140          PUSH    IX
150          PUSH    IY
160 LOOP     LD BC,(7F90)       ;GET DISTANCE DATA
170          LD HL,(7F92)
180          LD IX,FF02         ;GET SPEED
190 LOOP1    LD (IX+0),0
200          CALL DELAY         ;WAIT A FEW MILLISECONDS
210          DEC BC
220          LD A,B
230          OR C
240          JR NZ,LOOP1        ;LOOP UNTIL DIST. COMP.
250          DEC HL
260          LD A,H
270          OR L
280          JR NZ,LOOP1        ;LOOP UNTIL DIST. COMP.
290          CALL 02BB          ;GET READY TO RET. BAS.
300          LD A,L
310          CP FF
320          JR NZ,LOOP
330          POP IY             ;POP ALL REGISTERS
340          POP IX
350          POP BC
360          POP DE
370          POP AF
380          LD A,1E
390          LD I,A
400          RET                ;RETURN TO BASIC PROG.
410 DELAY    LD D,(7F94)        ;DELAY FOR MOTOR SPEED
420          LD A,D
430          OR E
440          JR NZ,DELAY
450          RET
460          END
```

BASIC ROBOT CONTROL PROGRAM

```
1 POKE 65283, 128
2 POKE 65280, 18+64
3 POKE 32596, 3
4 LET KL=61
6 LET KH=01
7 DIM A(8)
8 LET P1=0
9 GOTO 100
18 LET Z1=1
20 FOR X=1 TO 150
25 PRINT "CMD ";X;" ";
30 INPUT A$(X)
40 PRINT A$(X)
45 IF A$(X)(1 TO 2)="ST" THEN STOP
50 IF A$(X)(1 TO 1)="Q" THEN GOTO 100
60 NEXT X
70 CLS
100 LET N=X
105 FOR X=1 TO N
110 IF A$(X)(1 TO 2)="FD" THEN GOSUB 500
120 IF A$(X)(1 TO 2)="RV" THEN GOSUB 500
130 IF A$(X)(1 TO 2)="RR" THEN GOSUB 600
140 IF A$(X)(1 TO 2)="RL" THEN GOSUB 600
150 IF A$(X)(1 TO 2)="PO" THEN GOSUB 900
160 IF A$(X)(1 TO 3)="TRF" THEN GOSUB 700
170 IF A$(X)(1 TO 3)="TRR" THEN GOSUB 700
180 IF A$(X)(1 TO 3)="TLF" THEN GOSUB 700
190 IF A$(X)(1 TO 3)="TLR" THEN GOSUB 700
200 IF A$(X)(1 TO 2)="SP" THEN GOSUB 800
210 IF A$(X)(1 TO 2)="ST" THEN STOP
220 IF A$(X)(1 TO 2)="PU" THEN GOSUB 5000
230 IF A$(X)(1 TO 2)="PD" THEN GOSUB 5050
260 IF A$(X)(1 TO 2)="WT" THEN GOSUB 8000
262 IF A$(X)(1 TO 3)="WT1" THEN GOSUB 8040
264 IF A$(X)(1 TO 3)="WT2" THEN GOSUB 8060
266 IF A$(X)(1 TO 3)="WT3" THEN GOSUB 8080
268 IF A$(X)(1 TO 3)="WT4" THEN GOSUB 8100
270 IF A$(X)(1 TO 3)="WT5" THEN GOSUB 8120
272 IF A$(X)(1 TO 3)="WT6" THEN GOSUB 8140
274 IF A$(X)(1 TO 3)="WT7" THEN GOSUB 8160
300 NEXT X
305 CLS
310 GOTO 20
500 LET D=VAL A$(X)(3 TO 4)
505 LET D1= VAL A$(X)(5 TO 6)
507 LET D2= VAL A$(X)(7 TO 8)/100
510 LET D= (D*12)+D1+D2
520 GOSUB 1000
```

```
530 IF A$(X)(1 TO 2)="FD" THEN POKE 65280, P1+44
540 IF A$(X)(1 TO 2)="RV" THEN POKE 65280, 37+P1
550 GOSUB 2000
560 RETURN
600 LET DEG=VAL A$(X)(3 TO 5)
610 LET D=(DEG/360)*54.977871
620 GOSUB 1000
630 IF A$(X)(1 TO 2)="RR" THEN POKE 65280, 45+P1
640 IF A$(X)(1 TO 2)="RL" THEN POKE 65280, 36+P1
650 GOSUB 2000
660 RETURN
700 LET DEG=VAL A$(X)(4 TO 5)
710 LET D=(DEG/360)*56.155*2
720 GOSUB 1000
730 IF A$(X)(1 TO 3)="TRF" THEN POKE 65280, 40+P1
740 IF A$(X)(1 TO 3)="TRR" THEN POKE 65280, 32+P1
750 IF A$(X)(1 TO 3)="TLF" THEN POKE 65280, 4+P1
760 IF A$(X)(1 TO 3)="TLR" THEN POKE 65280, 5+P1
770 GOSUB 2000
780 RETURN
800 IF A$(X)(3 TO 4)="20" THEN GOSUB 3000
810 IF A$(X)(3 TO 4)="60" THEN GOSUB 3050
820 IF A$(X)(3 TO 5)="100" THEN GOSUB 3100
830 RETURN
900 GOSUB 2010
910 RETURN
1000 LET REV=(D/21.875)*8.667
1010 LET P=REV*200
1020 FOR Z=1 TO 8
1030 LET R1=P/16
1040 LET R3=INT R1
1050 LET R2=INT ((R1-R3)*16)
1060 LET A(Z)=R2
1070 LET P=R3
1080 NEXT Z
1090 LET LB=A(1)+A(2)*16
1100 LET HB=A(3)+A(4)*16
1110 LET L1=A(5)+A(6)*16
1120 LET H1=A(7)+A(8)*16
1140 POKE 32635,LB
1150 POKE 32636,HB
1160 POKE 32637,L1+1
1170 POKE 32638,H1
1180 POKE 32633,KL
1190 POKE 32634,KH
1200 RETURN
2000 RAND USR 32567
2010 POKE 65280, 18
2020 RETURN
3000 LET KL=185
3010 LET KH=03
```

COMMAND SYSTEM PROGRAM

```
10 CLS
20 INPUT "MODULE #";MN
30 IF MN=1 THEN FR=51
40 IF MN=2 THEN FR=46
50 IF MN=3 THEN FR=50
60 IF MN=4 THEN FR=44
70 IF MN=5 THEN FR=47
80 IF MN=6 THEN FR=45
90 CLS
100 PRINT "L TURNS LIGHTS ON AND OFF"
110 PRINT "P TURNS FILMSTRIP PROJECTOR ON"
120 PRINT "O TURNS FILMSTRIP PROJECTOR OFF"
130 PRINT "A ADVANCES THE FILMSTRIP PROJECTOR"
140 PRINT "H HALTS THE FILMSTRIP PROJECTOR"
150 REM TURN ON TRS-80 PORT:OUT 236,16
160 OUT 3, 130:REM INITIALIZE 8255 PPI
170 FL=0:F1=0:F2=0:CT=-1:REM SET UP FLAGS
180 A=INP(1) AND 7
190 REM TURN FILMSTRIP ON AND OFF
200 IF A=6 AND F2=0 THE GOSUB 280
210 REM TURN LIGHTS ON AND OFF
220 IF A=5 AND F1=0 THE GOSUB 320
230 REM ANVANCE PROJECTOR
240 IF A=3 THEN CT=CT+1:GOSUB 400
250 REM CHECK LIGHTS, PROJECTOR, AND ADVANCE
260 GOSUB 470
270 GOTO 180
280 F2=1
290 IF FL=0 THEN OUT 3,9:FL=1:RETURN:REM TURN ON PROJECTOR
300 IF FL=1 THEN OUT 3,8:FL=0:RETURN:REM TURN OFF PROJECTOR
310 RETURN
320 F1=1:REM TURN LIGHTS ON AND OFF
330 OUT 3,0:GOSUB 560:OUT 3,1:GOSUB 560:OUT 3,0
340 GOSUB 570
350 OUT 3,3:GOSUB 560:OUT 3,2
360 GOSUB 570
370 OUT 3,5:GOSUB 560:OUT 3,4
380 GOSUB 570
390 RETURN
400 REM ADVANCE FILMSTRIP PROJECTOR
410 OUT 3,6:GOSUB 570:OUT 3,7:GOSUB 570:OUT 3,6
440 IF CT >=FR THEN F1=0:F2=0
450 PRINT @600,"FRAME #";CT
460 RETURN
470 FOR T=1 TO 10
```

```
480 A$=INKEY$
490 IF A$="L" THEN GOSUB 580:PRINT @480,"LIGHTS":GOSUB 330
500 IF A$="P" THE FL=0:GOSUB 580:PRINT @480,"PROJECTOR ON":
    GOSUB 290
510 IF A$="O" THEN FL=1:GOSUB 580:PRINT @480,"PROJECTOR
    OFF":GOSUB 300
520 IF A$="A" THEN GOSUB 580:PRINT @480,"ADVANCE
    PROJECTOR":CT=CT+1:GOSUB 400
530 IF A$="H" THEN PRINT @480,"ADVANCE HALT":GOSUB
    580:B$=INKEY$:IF B$+"" THEN 530
540 NEXT T
550 RETURN
560 FOR D=1 TO 100:NEXT D:RETURN
570 FOR D=1 TO 75:NEXT D:RETURN
580 PRINT @480," "
590 FOR D=1 TO 50:NEXT D
600 RETURN
```

COMPUTER CHECKLIST

	M	T	W	T	F	M
1. TURN ON TRS-80	___	___	___	___	___	___
2. TURN ON ALL LIGHTS	___	___	___	___	___	___
3. TURN ON CONTROLLER	___	___	___	___	___	___
4. CHECK LIGHTS	___	___	___	___	___	___
5. CONNECT PROJ AND LOAD WITH CORRECT FILMSTRIP	___	___	___	___	___	___
6. RUN PROGRAM TO CHECK PROJ.	___	___	___	___	___	___
7. TURN ON AMPLIFIER AND CHECK FOR PROPER VOLUME	___	___	___	___	___	___
8. CHECK MICROPHONE	___	___	___	___	___	___
9. BREAK TRS-80 PROGRAM	___	___	___	___	___	___
10. RERUN PROG. WITH CORRECT MODULE NUMBER	___	___	___	___	___	___
11. WHEN COMPLETED CHECK ALL BATTERIES AND REPLACE IF NEEDED	___	___	___	___	___	___

ROBOT CHECKLIST

	M	T	W	T	F	M
I. PRELIMINARY CHECKS						
A. CONNECT TV TO ROBOT	___	___	___	___	___	___
B. TURN TV ON	___	___	___	___	___	___
C. CONNECT VOICE CASS. TO ROBOT (USE BLACK) 1. REWIND TAPE 2. SET TO CORRECT BEGINNING 3. CONNECT ROBOT SPEAKER 4. CONNECT REMOTE FROM ROBOT 5. PRESS PLAY	___	___	___	___	___	___
D. CONNECT KEYBOARD TO ROBOT	___	___	___	___	___	___
E. CONNECT 12V BAT. TO POWER ROBOT	___	___	___	___	___	___
F. CONNECT 6V BAT TO MOUTH CIRCUITS	___	___	___	___	___	___
G. ALIGN ROBOT TO FLOOR MARKS	___	___	___	___	___	___
II. RUN ROBOT PROGRAMS						
A. INSERT PROGRAM CASS REWIND TO BEGIN	___	___	___	___	___	___
B. TURN COMPUTER ON	___	___	___	___	___	___
C. LOAD MOTOR DRIVE PROG. TYPE RUN!	___	___	___	___	___	___
D. LOAD ROBOT BASIC CONTROL PROG	___	___	___	___	___	___
E. TYPE "GOTO 1"	___	___	___	___	___	___
F. PRESS ENTER	___	___	___	___	___	___

G. DISCONNECT CASS. ___ ___ ___ ___ ___ ___

H. DISCONNECT KEYBOARD ___ ___ ___ ___ ___ ___

I. DISCONNECT TV ___ ___ ___ ___ ___ ___

J. ENABLE MOT. SWITCHES ___ ___ ___ ___ ___ ___

K. OPEN DOOR ___ ___ ___ ___ ___ ___

L. CLOSE DOOR ___ ___ ___ ___ ___ ___

APPENDIX C

TEST CONTENT EVALUATION COMMITTEE

The following people have agreed to serve on the test content evaluation committee.

Kenneth R Washburn

1. Dr. Kenneth Washburn:
   Chairman, Electronic Technology Department

Bob Ray

2. Dr. Bob Ray:
   Chairman, Industrial Technology Department

James Harmon

3. Dr. James Harmon:
   Associate Chairman, Division of Industry

APPENDIX D

RANDOM GROUP ASSIGNMENT PROGRAM

```
5 REM MENU
10 DIM DAT$(200),GP1(30),GP2(30),GP3(30),GP4(30),TMP$(150),
DAT1$(200),TMP1$(150)
12 DIM GP1$(30),GP2$(30),GP3$(30),GP4$(30)
20 CLS:PRINT TAB(20), "1. CREATE A FILE"
30 PRINT TAB(20), "2. LOAD A FILE"
40 PRINT TAB(20), "3. SORT A FILE"
50 PRINT TAB(20), "4. GENERATE RANDOM GROUPS"
60 PRINT TAB(20), "5. PRINT A FILE"
65 PRINT TAB(20),"6. MODIFY A FILE"
67 PRINT TAB(20),"7. APPEND TO FILE"
70 PRINT TAB(20),"8. END"
80 PRINT:PRINT TAB(15),"SELECT ONE";:INPUT N
90 ON N GOSUB 110,260,350,1000,370,2000,3000,4000
100 GOTO 20
110 CLS:LINE INPUT "FILE NAME ";FIL$
120 OPEN FIL$ FOR OUTPUT AS #1
130 CLS:FL=0
140 PRINT"STUDENT #";N
150 INPUT "NAME";NM$
160 INPUT "MAJOR";MAJOR$
170 INPUT "TELEPHONE";TEL$
180 INPUT "TEST";TEST$
190 DAT$(N)=NM$+"%"+MAJOR$+"@"+TEL$+"*"+TEST$
195 IF FL=1 THEN RETURN
200 PRINT #1,DAT$(N)
210 PRINT
220 N=N+1
230 INPUT "CONT PRESS C";CO$: IF CO$="C" THEN 130
240 CLOSE
250 RETURN
260 CLS:LINE INPUT "FILE NAME ";FIL$
270 C=1
280 OPEN FIL$ FOR INPUT AS #1
290 IF EOF(1) THEN 330
300 INPUT #1,DAT$(C)
310 C=C+1
320 GOTO 290
330 CLOSE
340 RETURN
350 SHELL "SORT <A:STUD.DAT >A:STUD.SOR"
360 RETURN
370 CLS: INPUT "SCREEN (1) OR PRINTER (2)";SP
380 GOSUB 260
390 IF SP=1 THEN GOTO 510
```

```
400 CLS:PRINT TAB(12),"PLEASE WAIT WHILE THE PRINTER PRINTS"
410 LPRINT TAB(5) "NAME";TAB(25) "MAJOR";TAB(40) "TELEPHONE";
    TAB(56) "TEST":LPRINT:LPRINT
425 X=1
430 FOR CNT=1 TO (C/55)+1
440 FOR Z=1 TO 55
450 GOSUB 590
460 LPRINT X;NMS$ TAB(25);MAJ$ TAB(40);TEL$ TAB(50),TEST$
465 X=X+1
470 NEXT Z
480 LPRINT CHR$(12):NEXT CNT
490 CLS
500 GOTO 560
510 FOR X=1 TO C-1
520 GOSUB 590
530 PRINT X;NMS$ TAB(25);MAJ$ TAB(40);TEL$ TAB(50),TEST$
540 NEXT X
550 PRINT
560 INPUT"TO RETURN TO THE MAIN MENU PRESS RETURN";DUM
570 CLS
580 RETURN
590 L=INSTR(1,DAT$(X),"%")
600 ON ERROR GOTO 690:NMS$=LEFT$(DAT$(X),L-1)
610 L1=INSTR(L,DAT$(X),"@")
620 LNG=L1-L
630 MAJ$=MID$(DAT$(X),L+1,LNG-1)
640 L2=INSTR(L1,DAT$(X),"*")
650 LNG=L2-L1
660 TEL$=MID$(DAT$(X),L1+1,LNG-1)
670 L3=INSTR(L2,DAT$(X)," ")
680 TEST$=MID$(DAT$(X),L2+1,1)
690 RETURN
700 END
1000 RANDOMIZE TIMER
1010 GOSUB 260
1012 FOR X=1 TO C-1:DAT1$(X)=DAT$(X):NEXT X
1015 Z=1
1020 FOR X=1 TO C-1
1030 GOSUB 590
1040 IF TEST$="Y" THEN TMP$(Z)=DAT1$(X):Z=Z+1:DAT1$(X)=""
1050 NEXT X
1055 FOR X=1 TO Z:TMP1$(X)=TMP$(X):NEXT X
1057 X=1:FL=1:LP1=1:LP2=1
1060 RDN=INT(RND*(Z+1))
1070 IF TMP1$(RDN)="" THEN 1060
1080 IF FL=1 THEN GP1(LP1)=RDN: FL=2:LP1=LP1+1:GOTO 1095
1090 IF FL=2 THEN GP2(LP2)=RDN: FL=1:LP2=LP2+1
1095 X=X+1:IF X=Z THEN 1200
1100 TMP1$(RDN)=""
1110 GOTO 1060
1200 X=1:FL=1:LP3=1:LP4=1
```

```
1210 RDN=INT(RND*(C+1))
1220 IF DAT1$(RDN)="" THEN 1210
1230 IF FL=1 THEN GP3(LP3)=RDN:FL=2:LP3=LP3+1:GOTO 1250
1240 IF FL=2 THEN GP4(LP4)=RDN:FL=1:LP4=LP4+1
1250 X=X+1:IF X=Z THEN 1280
1260 DAT1$(RDN)=""
1270 GOTO 1210
1280 CNR=1
1285 FOR X=1 TO C
1290 IF DAT1$(CNR)="" THEN TMP1$(CNR)=DAT1$(CNR):CNR=CNR+1
1300 NEXT X
1310 FOR X=1 TO (Z/2)-1
1320 GP1$(X)=LEFT$(TMP$(GP1(X)),INSTR(1,TMP$(GP1(X)),"%")-1)
1322 GP2$(X)=LEFT$(TMP$(GP2(X)),INSTR(1,TMP$(GP2(X)),"%")-1)
1324 GP3$(X)=LEFT$(DAT$(GP3(X)),INSTR(1,DAT$(GP3(X)),"%")-1)
1326 GP4$(X)=LEFT$(DAT$(GP4(X)),INSTR(1,DAT$(GP4(X)),"%")-1)
1330 NEXT X
1335 N=1
1340 FOR M=1 TO C
1350  IF  DAT1$(M)<>"" THEN TMP1$(N)=LEFT$(DAT1$(M),
     INSTR(1,DAT1$(M),"%")-1):N=N+1
1352 NEXT M
1355 CNT=1:TEMP=X
1370 RDN=INT(RND*(N+1))
1380 IF TMP1$(RDN)="" THEN 1370
1390 GP1$(X)=TMP1$(RDN):X=X+1:TMP1$(RDN)="":
     IF X>=TEMP+N/4 THEN 1450
1400 CNT=CNT+1:IF CNT=N THEN 1450
1410 GOTO 1370
1450 CNT=1:X=TEMP
1460 RDN=INT(RND*(N+1))
1470 IF TMP1$(RDN)="" THEN 1460
1480 GP2$(X)=TMP1$(RDN):X=X+1:TMP1$(RDN)="":
     IF X>=TEMP+N/4 THEN 1550
1490 CNT=CNT+1:IF CNT=N THEN 1550
1500 GOTO 1460
1550 CNT=1:X=TEMP
1560 RDN=INT(RND*(N+1))
1570 IF TMP1$(RDN)="" THEN 1560
1580 GP3$(X)=TMP1$(RDN):X=X+1:TMP1$(RDN)="":
     IF X>=TEMP+N/4 THEN 1660
1590 CNT=CNT+1:IF CNT=N THEN 1660
1600 GOTO 1560
1660 X=TEMP
1665 FOR CNT=1 TO N
1680 IF TMP1$(CNT)<>"" THEN GP4$(X)=TMP1$(CNT):X=X+1
1710 NEXT CNT
1715 LPRINT, TAB(5) "GROUP 1" TAB(25); "GROUP 2" TAB(45);
     "GROUP3" TAB(65) "GROUP 4"
1720 LPRINT:LPRINT
1760 FOR CNT=1 TO X
```

```
1770 LPRINT CNT;".";GP1$(CNT) TAB(25);GP2$(CNT) TAB(45);
     GP3$(CNT) TAB(65);GP4$(CNT)
1780 NEXT CNT
1785 CLS:INPUT"STUDENT FORM (Y/N)";SF$:IF SF$="Y" THEN 1800
1790 RETURN
1800 LPRINT CHR$(27) "W" CHR$(1)
1810 FOR CNT=1 TO X:LPRINT TAB(15) GP1$(CNT):
     LPRINT TAB(15) "GROUP 1":LPRINT:LPRINT:NEXT CNT
1820 FOR CNT=1 TO X:LPRINT TAB(15) GP2$(CNT):
     LPRINT TAB(15) "GROUP 2":LPRINT:LPRINT:NEXT CNT
1830 FOR CNT=1 TO X:LPRINT TAB(15) GP3$(CNT):
     LPRINT TAB(15) "GROUP 3":LPRINT:LPRINT:NEXT CNT
1840 FOR CNT=1 TO X:LPRINT TAB(15) GP4$(CNT):
     LPRINT TAB(15) "GROUP 4":LPRINT:LPRINT:NEXT CNT
1850 LPRINT CHR$(27) "W" CHR$(0)
1860 GOTO 1790
2000 CLS:GOSUB 260
2010 CLS:LINE INPUT"NAME ";NME$
2120 FOR X=1 TO C-1
2125 TEMP$=LEFT$(DAT$(X),INSTR(1,DAT$(X),"%")-1)
2130 IF TEMP$=NME$ THEN 2150
2140 NEXT X
2145 CLS:PRINT"FILE NOT FOUND":FOR Z=1 TO 600:NEXT Z
2147 GOTO 2220
2150 PRINT DAT$(X):PRINT:LINE INPUT"NEW NAME AND DATA";NND$
2160 DAT$(X)=NND$
2170 LINE INPUT "FILE NAMEFIL$
2180 OPEN FIL$ FOR OUTPUT AS #1
2190 FOR X=1 TO C-1
2200 PRINT #1, DAT$(X)
2210 NEXT X
2215 CLOSE
2220 RETURN
3000 CLS:FL=1:N=1
3005 LINE INPUT"FILE NAME ?";FIL$
3007 OPEN FIL$ FOR APPEND AS #1
3010 GOSUB 140
3020 PRINT #1,DAT$(N)
3030 INPUT"CONT PRESS C";CO$:IF CO$="C" THEN 3010
3040 CLOSE:FL=0:RETURN
4000 END
```

APPENDIX E

MODULE #1 TEST

Read directions below before proceeding with test.

General Directions:

This examinations consists of 16 multiple choice questions each having four possible answers. Each question has one best answer so read very carefully each possible answer before answering the question.

All answers will be placed on a separate answer sheet and will be computer scored. Darken in neatly the space on the answer sheet corresponding to your answer. Do not place any unnecessary marks on the answer sheet or any marks on the test.

You will be given 10 minutes to complete the examination. Work carefully but steadily. Each question has a value of one point.

Proceed with the test.

MULTIPLE CHOICE

1. The Robot Institute of America (RIA) defines a robot as:
   * * A. a reprogrammable, multifunction, manipulator.
   * B. a mobile device.
   * C. a device that can recognize voices and speak.
   * D. a computer controlled mobile platform.

2. The *Heritage Dictionary* defines a robot as:
   * A. a reprogrammable, multifunction, manipulator.
   * B. a programmable mobile platform.
   * C. a humanoid machine that can speak and recognize voices.
   * * D. an external machine that behaves in a human manner.

3. The robot simulates a person by being:
   * A. jointed at the shoulder and elbow.
   * B. jointed at the wrist and fingers.
   * * C. both A and B.
   * D. neither A nor B.

4. The entire robot arm is referred to as:
   * A. a manipulator.
   B. a gripper
   C. end-of-arm tooling.
   D. end effector.

5. When robots are working on an assembly line:
   A. they must work by themselves.
   B. they must work with at least one other robot.
   * C. they can work jointly with other robots.
   D. robots cannot work on assembly lines.

6. In a computer controlled robot:
   A. the robot has a separate program from the computer.
   * B. the computer program controls the movements of the robot.
   C. the robot cannot be controlled by a computer.
   D. the robot programs the computer.

7. A robot that is multifunctional:
   A. can perform only one type of task.
   B. can perform many tasks using one program to control its motions.
   * C. can perform many tasks with the proper programming.
   D. can perform only welding.

8. Robots can:
   A. work in undesirable environments.
   B. handle parts that are too hot to handle by a human.
   C. work 24 hours a day without rest.
   * D. all the above.

9. Robots free people:
   A. from boring and hazardous work.
   B. to perform more creative work.
   C. to program robots.
   * D. all the above.

10. CAD means:
   A. Computer Aided Drafting system.
   * B. Computer Aided Design system.
   C. Comprehensive Auto Design system.
   D. none of the above.

11. The degree of sophistication a robot needs:
    - A. is the same no matter what job the robot performs.
    - B. is NOT dependent on the type of job the robot performs.
    - * C. is dependent on the type of job the robot performs.
    - D. is determined by how expensive the actuators are.

12. A robot gripper:
    - A. is the same for all types of robots.
    - * B. is different depending on the job the robot performs.
    - C. is normally shaped similar to a human hand.
    - D. normally has three fingers and an opposed thumb.

13. Robot wrists may:
    - A. bend up and down.
    - B. rotate.
    - C. sway side to side.
    - * D. all the above.

14. Robots could be used in:
    - A. outerspace.
    - B. undersea.
    - C. mining.
    - * D. all the above.

15. Robots in the future need more:
    - A. strength.
    - * B. degrees-of-freedom.
    - C. sensors.
    - D. actuators.

16. Ultrasonic ranging systems:
    - A. estimate distances to objects.
    - * B. determine distances exactly to an object.
    - C. determines the shape of an object.
    - D. all the above.

MODULE #2 TEST

Read directions below before proceeding with test.

General Directions:

This examinations consists of 16 multiple choice questions each having four possible answers. Each question has one best answer so read very carefully each possible answer before answering the question.

All answers will be placed on a separate answer sheet and will be computer scored. Darken in neatly the space on the answer sheet corresponding to your answer. Do not place any unnecessary marks on the answer sheet or any marks on the test.

You will be given 10 minutes to complete the examination. Work carefully but steadily. Each question has a value of one point.

Proceed with the test.

MULTIPLE CHOICE

1. Robot joints are called:
   * A. axes
   B. grippers.
   C. movements.
   D. connections.

2. Robots can be:
   A. high technology robots.
   B. low technology robots.
   C. medium technology robots.
   * D. all the above.

3. Low technology robots are sometimes called:
   A. move-and-place robots.
   B. pick-and-move robots.
   C. slow technology robots.
   * D. pick-and-place robots.

4. A 3-axes robot has:
   A. vertical travel.
   B. column rotate.
   C. extend-retract.
   * D. all the above.

5. A 3-axes robot that has a vertical pivot has a:
   A. cylindrical work envelope.
   B. rectangular work envelope.
   C. circular work envelope.
 * D. spherical work envelope.

6. Low technology robots are used for:
   A. material handling.
 * B. pick-and-place operations.
   C. machine loading and unloading.
   D. all the above.

7. High technology robots have:
   A. 3 degrees of freedom.
 * B. 5 to 10 degrees of freedom.
   C. 7 degrees of freedom.
   D. 1 to 3 degrees of freedom.

8. Common power sources used for robots are:
   A. pneumatic, hydraulic, and mechanical.
   B. batteries, electric motors, and solar energy.
 * C. pneumatic, hydraulic, and electric.
   D. both A and B.

9. The most reliable system is:
   A. hydraulic.
   B. electric.
   C. mechanical.
 * D. pneumatic.

10. The system that provides the greatest power is:
   A. electric.
 * B. hydraulic.
   C. pneumatic.
   D. mechanical.

11. The most reliable hydraulic power source is:
 * A. the piston hydraulic actuator.
   B. the hydraulic motor.
   C. the hydraulic stimulator.
   D. the hydraulic lift.

12. Strain gauges are used in robots to:
   A. determine manipulator position.
   B. determine gripper position.
   C. determine wrist movement.
 * D. determine gripper force.

13. Limit switches are used in robots to:
    - A. limit gripper pressure.
    - B. indicate position of the manipulator to the controller.
    - * C. limit maximum position of manipulator.
    - D. none of the above.

14. Ultrasonics are used in robots:
    - A. to determine distance to objects.
    - B. to sense motion.
    - * C. both A and B.
    - D. neither A nor B.

15. The main difference between robots and hard automation is:
    - A. robots cannot make mistakes.
    - * B. robots have the ability to "learn".
    - C. robots are easier to work with.
    - D. robots can move.

16. Controllers that are used in some robots are actually:
    - A. drum controllers.
    - * B. computers.
    - C. memories.
    - D. relays.

MODULE #3 TEST

Read directions below before proceeding with test.

General Directions:

This examinations consists of 16 multiple choice questions each having four possible answers. Each question has one best answer so read very carefully each possible answer before answering the question.

All answers will be placed on a separate answer sheet and will be computer scored. Darken in neatly the space on the answer sheet corresponding to your answer. Do not place any unnecessary marks on the answer sheet or any marks on the test.

You will be given 10 minutes to complete the examination. Work carefully but steadily. Each question has a value of one point.

Proceed with the test.

MULTIPLE CHOICE

1. Industry wide standards for robots:
   A. are common throughout industry.
   * B. do NOT exist.
   C. are used to set the mechanical limits of robots.
   D. are examples of how well the robot industry is organized.

2. The deviation of the wrist in following a straight line:
   * A. is a measurement of accuracy.
   B. is a measurement of reliability.
   C. is a measurement of payload.
   D. is a measurement of durability.

3. Applying glue to a part repeatedly requires:
   A. high accuracy.
   B. low reliability.
   C. the robot to be very quick.
   * D. the robot to have a high reliability.

4. Higher degrees of reliability and accuracy are more easily obtained in robots that:
   * A. have few axes.
   B. have many degrees of freedom.
   C. have large grippers.
   D. have small manipulator.

5. Devices attached to the robot are considered to be part of:
   A. the robot.
   B. the manipulator.
   C. the wrist.
   * D. the payload.

6. The payload of a robot is determined by:
   A. the number of axes a robot has.
   B. the strength of the gripper.
   * C. the strength of the motor or actuator.
   D. the length of the robot's gripper.

7. Grippers are designed for:
   A. general applications.
   B. specific applications.
   * C. both A and B.
   D. neither A nor B.

8. Types of standardized tooling are:
   A. welding tips.
   B. spot welders.
   C. gluing guns.
   * D. all the above.

9. A method that might be used to increase the efficiency of a robot is to use:
   A. a single gripper.
   B. a robot with a higher payload.
   * C. a robot with two grippers.
   D. a robot that has two axes.

10. The most sophisticated method for programming a robot is with:
   * A. a CAD.
   B. a teach pendant.
   C. a keyboard.
   D. a joystick.

11. One strength of robots in relation to people is:
    * A. that the robot's program serves as a template.
    B. that it can perform only one function very quickly.
    C. that it can perform many tasks very slowly.
    D. that it can perform only one task well.

12. A major advantage of the robot over humans is:
    A. the ability to move very quickly.
    B. to handle hot loads.
    C. to be mounted in awkward positions.
    * D. all the above.

13. A vision system for a robot would consist of:
    A. a camera.
    B. a sophisticated electronic system.
    C. a computer with software.
    * D. all the above.

14. Control units with larger memories can:
    A. handle shorter programs.
    B. handle more complex programs.
    * C. handle longer programs.
    D. both B and C.

15. One problem that is slowing the development of robots is:
    * A. a common language for all industrial robots.
    B. the speed at which robots can work.
    C. the lack of skilled repair technicians.
    D. the difficulty in finding repair parts.

16. Standardization will:
    A. make comparing robots easier.
    B. increase the standardization of end-of-arm tooling.
    C. increase compatibilities.
    * D. all the above

MODULE #4 TEST

Read directions below before proceeding with test.

General Directions:

This examinations consists of 16 multiple choice questions each having four possible answers. Each question has one best answer so read very carefully each possible answer before answering the question.

All answers will be placed on a separate answer sheet and will be computer scored. Darken in neatly the space on the answer sheet corresponding to your answer. Do not place any unnecessary marks on the answer sheet or any marks on the test.

You will be given 10 minutes to complete the examination. Work carefully but steadily. Each question has a value of one point.

Proceed with the test.

MULTIPLE CHOICE

1. The factor(s) that affect the decision of determining what type of robot is needed for a specific job is(are):
   - A. working environment.
   - B. need for accuracy.
   - C. performance of repetitive tasks.
   - * D. all the above.

2. One of the most common uses for robots in industry is:
   - A. assembly of automobiles.
   - B. maintenance of other robots.
   - * C. welding.
   - D. assembly of electronic equipment.

3. A spot welding robot uses:
   - A. a gripper to hold the welding rods.
   - * B. a spot welding machine as an end-of-arm tooling.
   - C. a mig welder to spot weld automobiles.
   - D. specially designed gas tips to weld auto bodies.

4. A major advantage of using spot welding robots on autos is:
   - A. one robot can be used to weld all points.
   - * B. several units can be positioned in one cell.
   - C. one unit can be positioned to weld only one point.
   - D. none of the above.

5. MIG stands for:
   - * A. Metal Inert Gas.
   - B. Mild Industrial Gas.
   - C. Medium Insulated Garage.
   - D. none of the above.

6. When robots are used in plasma welding or coating:
   - * A. the robot frequently has to be protected.
   - B. the robot requires NO protection.
   - C. robots cannot be used for this purpose.
   - D. the robot needs only two degrees of freedom.

7. Robots are used frequently for spray painting applications because:
   - A. they are extremely fast.
   - * B. they can be programmed to use less paint.
   - C. they have the ability to move slowly.
   - D. robots are not used for spray painting.

8. Robots are used in adhesive applications because:
   - A. they are cost effective.
   - B. they are impervious to fumes.
   - * C. both A and B
   - D. neither A nor B.

9. Robots are used to load and unload machine tools because:
   - A. robots service several machine tools.
   - B. robots can handle parts that humans cannot.
   - C. robots can work with CNC machines.
   - * D. all the above.

10. A flexible manufacturing system:
    - A. uses a computer to control the action of one machine and one robot.
    - * B. uses a central computer to control each of the machines that are in the system.
    - C. has one robot feeding two CNC machines.
    - D. has many CNC machines that feed one robot.

11. A difficult task to program a robot to performs is:
    - A. spray painting.
    - B. spot welding.
    - C. machine tooling loading and unloading.
    - * D. palletizing.

12. A laser can be used to:
    - A. weld components.
    - * B. measure the size of finished parts.
    - C. detect distances to an object.
    - D. cut thick sheet metal.

13. In casting factories robots are used:
    - A. frequently to assemble engines into complete units.
    - * B. to lift heavy objects that are difficult to handle by a human.
    - C. remove the casting sand from a casting.
    - D. all the above.

14. In pressing operations robots are used:
    - * A. primarily for safety reasons.
    - B. to remove hot parts from the press.
    - C. to insert finished parts into the press.
    - D. to lift heavy parts into the press.

15. In the nuclear industry:
    - A. robots have been used extensively.
    - * B. robots have been used on a limited basis.
    - C. robots are used to assemble reactors.
    - D. robots are used to insert radioactive cores into reactors.

16. Robots:
    - A. are used to replace workers in jobs that are dangerous.
    - B. are used to replace workers in tedious jobs.
    - C. are used to increase productivity.
    - * D. all the above.

MODULE #5 TEST

Read directions below before proceeding with test.

General Directions:

This examinations consists of 16 multiple choice questions each having four possible answers. Each question has one best answer so read very carefully each possible answer before answering the question.

All answers will be placed on a separate answer sheet and will be computer scored. Darken in neatly the space on the answer sheet corresponding to your answer. Do not place any unnecessary marks on the answer sheet or any marks on the test.

You will be given 10 minutes to complete the examination. Work carefully but steadily. Each question has a value of one point.

Proceed with the test.

MULTIPLE CHOICE

1. An audit form would be used to:
   * A. determine if there is an application for a robot.
   B. determine the cost of a robot.
   C. determine the effectiveness of a robot.
   D. determine how much work is completed by a robot.

2. Payload is the weight of the:
   * A. end-of-arm tooling and weight of workpiece.
   B. gripper.
   C. manipulator and base.
   D. workpiece only.

3. When the weight of a robot's payload increases:
   A. accuracy increases.
   B. accuracy remains the same no matter what the weight.
   * C. accuracy decreases.
   D. reliability increases.

4. Work envelope takes into account:
   * A. the maximum moves on all axes of the robot.
   B. the minimum moves on a few axes of the robot.
   C. the payload of the robot.
   D. the minimum extension of the gripper.

5. The length of time for a robot to complete a given operation is:
   A. operation time.
   B. recycle time.
   * C. cycle time.
   D. repair time.

6. As the complexity of a robot task increases:
   A. mean time to repair increases.
   B. operation time increases.
   * C. the number of robot axes increase.
   D. recycle time decrease.

7. One of the major responsibilities of the setup person is:
   * A. to ensure that the robot is properly oriented.
   B. to maintain the robot`s gripper.
   C. to maintain the robot.
   D. to program the robot to do specific task.

8. In a stationary robot:
   A. the robot moves to the work area.
   B. safeguards must be used to prevent other robots from interfering with the operation of the stationary robot.
   * C. safeguards must be used to prevent humans from entering the work envelope.
   D. the robot must be interfaced with a machine tool.

9. If the perimeter of a robot's work envelope is entered by a human:
   A. the robot must keep working.
   * B. the robot must have sensors that will cause it to stop operating.
   C. the robot should slow down to avoid the human.
   D. the robot has no need for sensors since the controller can sense the heat given off by a human.

10. One of the most common sensing devices for a perimeter is:
    - A. a relay.
    - B. a thermocouple.
    - * C. a photoelelectric sensor.
    - D. a laser beam.

11. Programming a robot is:
    - A. moving the robot to a specified workplace.
    - B. done normally with a keyboard.
    - C. is not important to the operation of the robot.
    - * D. teaching the robot to perform the necessary tasks.

12. Computer simulation is the same as:
    - * A. off-line programming.
    - B. on-line programming.
    - C. lead-through programming.
    - D. teach pendant programming.

13. Once a robot is installed and its performance checked:
    - A. the robot can be moved to its permanent operating station.
    - B. the robot should be programmed to do its assigned task.
    - * C. the robot can be put into operation.
    - D. the robot must be overhauled.

14. The MTBF is:
    - A. the average time the robot is shut down.
    - B. the length of time required to fix the robot.
    - C. the time required to set up the robot.
    - * D. the average time the robot will operate before it needs repair.

15. A maintenance program must take into account:
    - * A. the power requirements of a robot.
    - B. the strength of the robot.
    - C. the number of axes a robot has.
    - D. the work envelope of the robot.

16. In a typical robot workcell approximately ______% of the cost can be attributed to the cost of the robot.
    - * A. 20
    - B. 80
    - C. 100
    - D. 60

MODULE #6 TEST

Read directions below before proceeding with test.

General Directions:

This examinations consists of 16 multiple choice questions each having four possible answers. Each question has one best answer so read very carefully each possible answer before answering the question.

All answers will be placed on a separate answer sheet and will be computer scored. Darken in neatly the space on the answer sheet corresponding to your answer. Do not place any unnecessary marks on the answer sheet or any marks on the test.

You will be given 10 minutes to complete the examination. Work carefully but steadily. Each question has a value of one point.

Proceed with the test.

MULTIPLE CHOICE

1. Human factors in robotics:
   * A. are those things that concern people when they have to work with robots.
   B. have no effects on the selection of the type of robot for a particular application.
   C. will have an effect on the selection of a robot for a particular application.
   D. none of the above.

2. Once a committee is familiar with robots and robot applications:
   * A. it should examine and specify robot systems.
   B. it should immediately purchase a robot for a particular application.
   C. it should contact a consulting firm and have it select a robot.
   D. it should report to the president of the company its findings.

3. To achieve the maximum educational benefit from the first robot installation:
   A. the robot must be placed in a safe environment.
   * B. a good application must be selected.
   C. the robot task must be complex.
   D. the robot must be used for loading and unloading purposes only.

4. A popular first installation for robots is:
   * A. spray painting.
   B. assembly.
   C. welding.
   D. all the above.

5. Initial success in the use of robots:
   A. makes it difficult to determine other uses for robots.
   * B. makes it easier to determine other uses for robots.
   C. is imperative if robots are to be used in other applications.
   D. is not important if robots are to be used in the future.

6. When robots are employed to perform a particular task, management must take into account:
   A. other applications that the robot may be able to do.
   * B. personnel displacement.
   C. how many machine tools will be required to assist the robot.
   D. none of the above.

7. Skills assessment for robotics is normally none by:
   A. the labor unions.
   B. consulting firms.
   * C. management.
   D. state employment office.

8. The goal(s) of management in the installation of robots is(are):
   A. that the installation is done smoothly.
   B. that the application is effective.
   C. that safety considerations are met.
   * D. all the above.

9. One major concern that employers will have to deal with when implementing robots is:
   - A. the cost of the robot.
   - B. the safety factors associated with installing robots.
   - * C. the perception that masses of employees will be replaced by robots.
   - D. the replacement of older machine tools by the robots.

10. When robots are used to displace workers:
    - A. the jobs created are generally unskilled.
    - B. the jobs created are usually unsafe.
    - C. no jobs are created.
    - * D. the jobs created are generally technical in nature.

11. Generally one robot can be used to replace ______ human workers.
    - A. 1
    - * B. 2
    - C. 3
    - D. 4

12. By 1990 there will be approximately ________ robots in the United States.
    - * A. 60,000 to 70,000
    - B. 100,000
    - C. 1 million
    - D. 150,000 to 200,000

13. In the pure sense robots:
    - A. CAN save jobs.
    - * B. CANNOT save jobs.
    - C. CAN create jobs.
    - D. have NO impact on the creation of jobs.

14. Robots are especially important to companies:
    - A. that have high labor costs.
    - * B. that face stiff international competition.
    - C. that are labor intensive.
    - D. that have many safety hazards.

15. One of the best ways to educate managers and workers about robots is:
    - A. hire a consulting firm.
    - B. send a management team to an industrial seminar on robots.
    - * C. to visit other industries that have implemented robots.
    - D. to have them read a book on robotics.

16. The robot shown in the filmstrip that could be used for education or light assembly is the:
    - A. HERO robot.
    - * B. Rhino robot.
    - C. Armatrol robot.
    - D. none of the above.

APPENDIX F

Southeastern Oklahoma State University
Durant, Oklahoma, 405-924-0121
Division of Industry

M E M O R A N D U M

TO: Doug Keenan

FROM: Alvin M. White A. W.

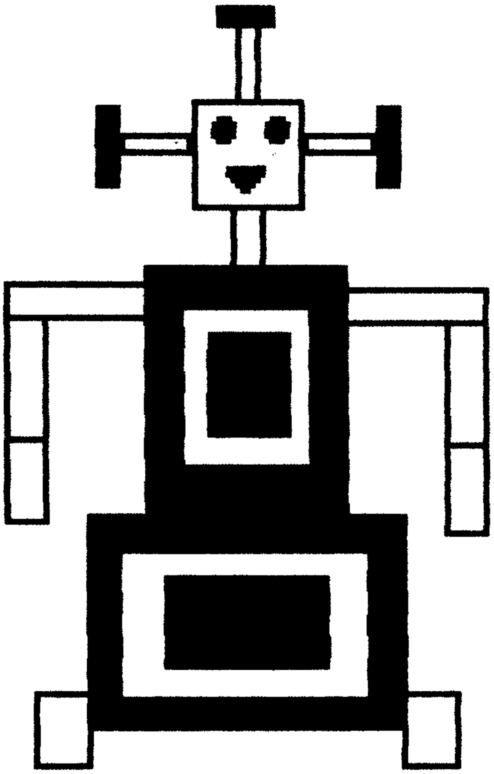
SUBJECT: Use of students and classroom for Dissertation

DATE: July 26, 1985

Mr. Keenan may solicit volunteers from the Division of Industry. Volunteer students will be excused from classes to participate in the experiment.

Mr. Keenan may also use Room ET 306 from 8 - 12 for a period of six consecutive days.

APPENDIX G



LEARN ROBOTICS IN SIX DAYS

SEE MR. KEENAN

IN ET 323 OR CALL

924-0121 EXT 415

APPENDIX H

Southeastern Oklahoma State University
Durant, Oklahoma, 405-924-0121
Vice President for Instruction

November 1, 1985

TO WHOM IT MAY CONCERN

Mr. Doug Keenan is developing student data for a research project. To obtain this data, a series of tests will be administered to students These students will need to miss only one hour of your class to participate. If it is possible for you to allow this student to participate, it would be appreciated.

E. Sturch
Ernest Sturch
Provost

SC

APPENDIX I

FORM 2
USE OF HUMAN SUBJECTS

INFORMED CONSENT

NAME OF SUBJECT ____

1. I here by give consent to ______________________ to perform or supervise the following investigational procedure or treatment:

____

____

2. I have (seen, heard) a clear explanation and understand the nature and purpose of the procedure or treatment; possible appropriate alternative procedures that would be advantageous to me (him, her); and the attendant discomforts or risks involved and the possibility of complications which might arise. I have (seen, heard) a clear explanation and understand the benefits to be expected. I understand that the procedure or treatment to be performed is investigational and that I may withdraw my consent for my (his, her) status. With my understanding of this, having received this information and satisfactory answers to the questions I have asked, I voluntarily consent to the procedure or treatment designated in Paragraph 1 above.

____
DATE

SIGNED: ____________________ SIGNED: ______________________
WITNESS SUBJECT

or

SIGNED: ____________________ SIGNED: ______________________
WITNESS PERSON RESPONSIBLE

Instructions to persons authorized to sign:

If the subject is not competent, the person responsible shall be legal appointed guardian or legally authorized representative.
If the subject is a minor under 18 years of age, the person responsible is the mother or father or legally appointed guardian.
If the subject is unable to write his name, the following is legally acceptable: John H. (His X Mark) Doe and two (2) witnesses.

DAY IN NOVEMBER

TIME	4	5	6	7	8	11
8:00 AM	G1	G2	G3	G4	G1	G2
9:00 AM	G2	G3	G4	G1	G2	G3
10:00 AM	G3	G4	G1	G2	G3	G4
11:00 AM	G4	G1	G2	G3	G4	G1

GROUP SCHEDULE

APPENDIX J

ROBOT SPEECH

1. Good morning, I am glad that you could attend.
2. This morning you will view module number________.
3. This module will take approximately 15 minutes to show.
4. At the end of the module you will be given a short exam over the material presented.
5. Please pay close attention to what I have to say.
6. I will now turn off the lights and begin the presentation.

==

Control frequencies to turn the lights off and the projector on are inserted here. The module presentation begins at this point and runs between eleven and fifteen minutes.

==

7. I will now turn off the projector and turn on the lights.
8. A test will now be given.
9. A test booklet should be in front of you.
10. Please turn it over and remove the ScanTron form.
11. Write your name and group number on the ScanTron form. Do not write on the test!
12. Mark the answer that you think best on the ScanTron form using a number two pencil.

13. You will have approximately 10 minutes to complete the test.

14. If you complete the test before the allotted time, please sit quietly until I announce that the test is over.

15. You may now begin.

==

The robot times the subjects for ten minutes.

==

16. The test is over.

17. Please turn your test booklets over and leave the ScanTron form in front of you.

18. I will now return to my starting position.

19. Please do not leave until I have returned.

20. Please no not forget your scheduled time for the next session.

21. Thank you and have a good day.

22. You may now leave.

CLASSROOM MONITOR SPEECH

1. Good morning, I am glad that you could attend.
2. This morning you view module number _________.
3. This module will take approximately 15 minutes to show. At the end of the module you will be given a short exam over the material presented. Please pay close attention to what the module has to say.
4. Module presentation goes here- 11 to 15 minutes.
5. I will now turn off the projector and turn on the lights.
6. A test will now be given.
7. A test booklet should be in front of you.
   Please turn it over and remove the ScanTron form.
   Write your name and group number on the ScanTron form.
   Do not write on the test.
   Mark the answer that you think best on the ScanTron form using a number two pencil.
   You will have approximately 10 minutes to complete the test.
   If you complete the test before the allotted time, please sit quietly until I announce that the test is over.
   You may now begin.
8. Wait ten minutes- time accurately.
9. The test is over.
10. Please turn your test booklets over and leave the ScanTron form in front of you.

11. Please do not forget you scheduled time for the next session.
12. Thank you and have a good day.
13. You may now leave.

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