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The effects of an interactive computerized multimedia tutorial on knowledge gain in modular fixturing design concepts

Veekit O'Charoen
University of Northern Iowa

THE EFFECTS OF AN INTERACTIVE COMPUTERIZED MULTIMEDIA TUTORIAL ON KNOWLEDGE GAIN IN MODULAR FIXTURING DESIGN CONCEPTS

A Dissertation

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Doctor of Industrial Technology

Approved:

Dr. Ali E. Kashef, Chair

Dr. Douglas T. Pine, Co-Chair

Dr. Teresa K. Hall, Committee Member

Dr. Andrew R. Gilpin, Committee Member

Dr. Eugene V. Wallingford, Committee Member

Veekit O'Charoen

University of Northern Iowa

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Dr. John W. Somervill
Dean of the Graduate College

Veekit O'Charoen

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ABSTRACT

This study was designed to compare student knowledge gain from learning modular fixturing design concepts by computer tutorial versus traditional lecture. The use of computer tutorial to support engineering and technology classroom instructions has been a major issue for many studies. The undergraduate curricula in engineering and technology are becoming increasingly complex due to the today's modern wide variety of manufacturing processes. The concept of modular fixturing in tool design course is one of the technical competencies which most industries would like graduates to be able to apply their knowledge to real-world problems and situations.

An interactive computerized multimedia tutorial named ToolTRAIN was developed and administered to undergraduate students in the Industrial Technology program at the University of Northern Iowa. By integrating information in a graphical manner such as 3D visualization through animation, ToolTRAIN demonstrated how several modular fixturing components can be assembled with a wide variety of workpieces.

A quasi-experimental design employing pre- and post-instruction tests was utilized for the study. Two preexisting groups of students were assigned to either the experimental or control group. Both groups were instructed on the same general topics covered in this study. A pretest was given to both groups. Three hours were used to teach the control group the concepts and theories of modular fixturing design concepts by lecture. On the other hand, the experimental group was expected to utilize ToolTRAIN for three hours. The posttest was administered to all subjects to measure knowledge gain of modular fixturing design concepts after the instruction. The data were analyzed using

t tests to compare group mean of change scores. All hypotheses were tested at the .05 level of significance.

This research indicated that there were significant differences between the computer tutorial program and lecture method. The experimental (computer tutorial) group achieved significantly higher improvement in scores than the control (lecture) group. Also, the learning time actually spent using ToolTRAIN was less that for the control group.

Based on this research it was concluded that the ToolTRAIN interactive multimedia tutorial program can be used as an effective teaching method for modular fixturing design concepts. Future research should expand the sample size used in the investigation with tighter control of control group module content. ToolTRAIN can also be used for more complex concepts of modular fixturing system and applications.

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CHAPTER I

INTRODUCTION

Motivation and Background

From the time that computers became available in schools and universities, many educators have begun to concentrate more on developing student ability to learn independently. They have started teaching students how to learn the material, rather than teaching them the material itself. As a result, computer assisted instruction (CAI) has become an instructional aid, implemented by computer software. Since computers have brought a capability of multimedia, many educators along with engineering, science, technology and computer professionals have tried to implement training materials as an alternative to conventional classroom instruction.

The undergraduate curricula in manufacturing engineering and technology are becoming increasingly complex due to the today's modern manufacturing concepts such as flexible manufacturing systems (FMSs) through computer integrated manufacturing (CIM). Therefore, flexible fixturing has become an important issue in FMSs and CIM (Nee & Kamar, 1991). The engineering efforts required for custom modular fixturing design are growing with respect to the number of components per part. Without experiences in tool design, manual designs are prone to human errors and the iterative manufacturing design process may result in a lengthy development period. In order to address this issue, many colleges and universities in the United States are required to prepare their students to learn more about tool design concepts.

Modular Fixturing

Modular fixtures were originally developed for small batch production to reduce the fixturing cost, where the dedicated fixtures were not economically feasible (Rong & Bai, 1997). The flexibility of the modular fixture is derived from the large number of fixture elements which may be bolted to a baseplate (Nee & Kamar, 1991). Modular fixture elements can be dis-assembled after processing a batch of parts and re-used for new parts. This allows more freedom and creates an atmosphere where the designer can look for more economical alternatives. Even when dedicated tooling is planned for a large production run, modular fixtures can be used to establish the basic design of the dedicated work holder (Hoffman, 1987). This helps the designer spot any design errors in either parts or the workholder before the dedicated fixture goes into production.

Multimedia

As used during the past several years, the term "multimedia" refer to designating or pertaining to a form of artistic, educational, or commercial communication in which more than one medium is used (Simpson & Weiner, 1989). Literally, it refers to anything that uses more than one way to present information. In the computer dictionary, multimedia refers to a computer-based method of presenting information by using more than one medium of communication, such as text, graphics, sound, and emphasizing interactivity (Pfaffenberger, 1999). Today, multimedia contains a combination of text, graphics art, sound, animation, and video elements. This definition reflects advances in computer hardware which makes it possible for visual images to be combined with animation video and audio. When multimedia technology allows a user (the viewer of multimedia project) to control what and when elements are delivered, it is called interactive multimedia (Vaughan, 1996). This process offers user some control by gaining and holding their attention to the information. Multimedia enhances the learning process by promoting learner control. It was reported by Gate (1994) and Airir (1995) that people remember 10% of what they hear, but 80% of what they experience directly. By adopting learning theories, multimedia technologies enable educators as never before to help learners at different ages to shift away from a memorization mode to a thinking mode.

In this study, the objective was to design a computerized tutorial using a multimedia system thus making it possible to represent many concepts such as 3D shapes, animation, and sound. The purpose of teaching the design of modular fixtures in a tool design course is to introduce students to some rules, laws, and methods to simplify modular fixturing functions. It is difficult for a novice to understand and learn a concept of modular fixturing design in a short amount of time. Hence, the use of series of computer-based lessons may be helpful. Thus, a computer program based on a concept of modular fixtures was developed to establish a meaningful introduction to a tool design course for students.

The design of this program was rooted in the theories of learning and instruction. Based on an analysis of learning needs, this program was developed as a tutorial employing CAI. All the learning environments were set up before students started the program. Some units used an animation program to show a virtual view of how components are assembled and their function, as necessary. The computer aided instruction program was developed to provide an easier and more interesting way for novices to learn a modular fixturing concept.

Statement of the Problem

The problem of this study was to evaluate undergraduate industrial technology students' cognitive knowledge of the concept of modular fixturing, comparing teaching effectiveness of two different instructional technologies, either computer tutorial techniques or the traditional lecture method.

Statement of Purpose

The primary purposes of this study were:

1. To develop and demonstrate the educational effectiveness of using an interactive computerized multimedia tutorial to teach a concept of modular fixture design at the undergraduate level, and

2. To investigate whether two different instructional methods (traditional lecture vs. computer tutorial) are fundamentally effective in teaching the concept of modular fixture design.

Statement of Need

Designing skills in modular fixtures is important. Traditional teaching methods (lectures) have been used to teach the concepts of jigs and fixtures. These concepts are typically difficult to understand for students taking tool design for the first time. A few factors that may account for this are as follows:

1. Appropriate training materials have not been designed to aid in teaching these concepts.

2. Textbooks have not fully explained the concepts and theory of tool design related to modular fixtures.

3. Appropriate work periods were not scheduled as part of the design activities. Some instructors were apt to assign too much or too little work for the allotted time period (Cushman, 1995).

4. The industrial technology program is expanding rapidly. Students majoring in other areas such as technology education can also benefit from tool design class.

Research Questions

The questions to be addressed by the study were as follows:

Major question:

Can a general concept of modular fixture be learned as effectively through a computer tutorial as knowledge gained through traditional classroom instruction, as measured by traditional test scores?

Sub-questions:

1. Can basic concepts and principle of modular fixture be learned as effectively through a computer tutorial as knowledge gained through traditional classroom instruction, as measured by traditional test scores?

2. Can concepts of modular fixturing components be learned as effectively through a computer tutorial as knowledge gained through traditional classroom instruction, as measured by traditional test scores?

3. Can concepts of modular fixturing implementation be learned as effectively through a computer tutorial as knowledge gained through traditional classroom instruction, as measured by traditional test scores?

Hypotheses of the Study

Hypotheses were established for this study based upon the fact supportive data exists. Given the preceding research questions, the following hypotheses were proposed to facilitate analysis for the purpose of this study.

Research Hypothesis

On all test items representing knowledge of modular fixturing (basic concepts, principle, components and implementation), for students receiving instruction in the computer tutorial group will show at least as much improvement in assessed knowledge as those in the lecture group.

Null Hypotheses

Major null hypothesis. There is no significant difference between the increase in general performance on test scores of students who used computer tutorial and those who experienced the traditional teaching methods.

Sub-null Hypothesis 1. There is no significant difference between the increase in performance on knowledge test scores of basic concepts and principles of modular fixturing of students who used computer tutorial and those who experienced the traditional teaching methods.

Sub-null Hypothesis 2. There is no significant difference between the increase in performance on knowledge test scores of modular fixturing components of students who used computer tutorial and those who experienced the traditional teaching methods.

Sub-null Hypothesis 3. There is no significant difference between the increase in performance on knowledge test scores of modular fixturing implementation of students who used computer tutorial and those who experienced the traditional teaching methods.

Assumptions

As a result of various constraints associated with this experimental, the following assumptions were made with respect to this study:

1. The assigned sample size was sufficient for an estimation of population parameters.

2. The instruments (pre-test and post-test) had adequate reliability.

3. The two groups had equal variances and were normally distributed.

4. The introductory demonstration of the computer tutorial gave users sufficient training to operate the program correctly. Therefore, users were capable of activities involving proper storage, loading and execution of computer tutorial.

5. The external environment factors (i.e., CPU architectures, operating systems, CD-ROM speed, and room temperature) did not significantly affect this study.

Delimitation

This study was conducted in a computer lab, Industrial Technology Center, Department of Industrial Technology, University of Northern Iowa. ToolTRAIN was the only software tutorial used in the experimental treatment group.

Limitations

Due to the nature of this study, and due to the restrictions of resources and limitations of the facility begin used, the following limitations were made with respect to this study:

1. The participants of this study were limited to a group of students enrolled in the Industrial Technology Department.

2. The computer-based instruction program utilized in the experimental treatment group was limited in scope due to the time available for instruction to the following topics: (a) basic concepts and principles of modular fixturing; (b) modular fixturing components, mounting plate (grid holes and dowel systems), mounting plate (t-slot systems), mounting accessories, locators, and clamps; and (c) modular fixturing implementation for a specific part and machining.

3. The unit of observation in this study was the student. Because students did not receive the treatments concurrently, there was a possibility of violations of the assumption of independence by students sharing information with each other, both within groups and across treatment groups.

4. Changes in technology and the variety of computer programs may affect replication of this study.

Procedure of Study

In conducting this study, the following procedures were followed (Chen, 1995):

1. All the research problems were identified.
2. The literature related to modular fixtures and CAI was reviewed.
3. The population and sample subjects for this study were identified.
4. The dependent and independent variables were identified and labeled.
5. The pre-test and post-test instruments were developed.
6. The computer tutorial program was developed and refined.
7. The pretest was administered.
8. Both instruction methods were implemented.
9. The post-test was administered.

10. Research data were coded.

11. The data were analyzed by a statistics package.

12. A final report, summary, conclusions and recommendation were written based on research findings.

Definition of Terms

Special terms related to this study were used. The following terms were defined to clarify and standardize terms used in the research in this study.

Clamps: a group of devices specifically designed for holding the position of the part against the locators throughout the machining cycle (Hoffman, 1991).

Computer Aided Design (CAD): a major use of computer graphics in design processes, particularly for engineering and architectural systems, but almost all products are now computer designed (Hearn & Baker, 1997).

Computer Aided Fixture Design (CAFD): a use of computer to provide a fixture design which can ensure the machining quality in manufacturing processes (Rong & Bai, 1996). There are two major approaches in CAFD. The first one is the knowledge based, automated fixture design, where a geometric reasoning, kinematics analysis, or screw theory may be applied. The second is group technology (GT) based search and retrieval of existing fixture designs.

Computer Assisted Instruction (CAI): a use of computer as a tool to facilitate and improve Instruction. CAI programs use tutorials, drill and practice, simulation, and problem solving approaches to present topics, and they test the student's understanding (Sharp, 1996).

Computer Integrated Manufacturing (CIM): the umbrella acronym for a host of automation technologies in the manufacturing environment. It refers to the integrated use of computers in all sections of enterprise, from the planning of production through the design and manufacture of a product up to the assurance of good quality (Markert, 1997).

Computer Tutorial: placing a computer in the role of a tutor. Information is presented by the computer in small segments. Visual animation or sound are sometimes employed to clarify new information. A computer tutorial asks questions of the learner and evaluates the responses. Incorrect responses might result in a repetition of the relevant information. Correct learner responses are reinforced by the computer program much as they would be by a human tutor (Price, 1991).

CPU: a part of the computer system where the manipulation of symbols, number, and letters occurs, and it controls the other parts of the computer system (Laudon & Laudon, 1996).

Fixture: a production tool that locates, holds and supports the work securely so the required machining operations can be performed (Hoffman, 1991).

Flexible Manufacturing Systems (FMSs): an arrangement of computer controlled several machine tools with interlinked material and information flow, which can automatically and simultaneously manufacture different parts with different sequences of operation in one system (Adil, Kasilingam, & Taboun, 1992).

Grid Holes and Dowel Systems: a use of a simple flat plate as a base plate to attach the required locators and clamps needed to fixture a part. Grid holes and dowel systems are made with two different styles of holes. One style uses alternating tapped holes separated with dowel-pin holes. The second style combines both the locating and mounting functions into the same hole by mounting a locating bushing on top of a tapped hole (Hoffman, 1991).

Locators: a group of components designed for reference on the workpiece and to ensure repeatability. The more common modular locators are support cylinders, screw rest pads, round/diamond locating pins, edge support, extension supports, screw jacks, manual work supports, adjustable stops and v blocks (Carr Lane Mfg. Co., 1992).

Modular Fixtures: a workholding system using a series of standardized components for building specialized workholders. A modular workholder is assembled from a variety of standard off-the-shelf tooling plates, supports, locating elements, clamp, and similar components (Carr Lane Mfg. Co., 1992).

Mounting Accessories: a group of components specifically designed for mounting the wide variety of modular components. The more common mounting accessories include locating screws, riser blocks, riser cylinders and adaptors (Carr Lane Mfg. Co., 1992).

Mounting plate: a main structure element of any modular system. These elements are available in several forms for maximum design flexibility. The two primary forms of modular systems available today are grid holes with dowel and t-slot systems. In addition, each tooling plate and block variation comes in a variety of sizes for a wide range of application (Carr Lane Mfg. Co., 1992).

Tool Design: a specialized area of manufacturing engineering which comprises the analysis planning, design, construction, and application of tools, methods and procedures necessary to increase manufacturing productivity (Society of Manufacturing Engineers, 1998).

T-Slot Systems: a use of a series of precisely machined base plates, mounting blocks, and other elements having machined and ground t-slots. These are used to mount and attach the additional accessories. T-slots are machined exactly perpendicular and parallel to each other (Hoffman, 1991).

CHAPTER II

REVIEW OF LITERATURE

According to the Manufacturing Education Plan with the study of Critical Competency Gaps (Society of Manufacturing Engineers, 1999), product and process design which includes the principle of concurrent engineering, computer aided design techniques, modeling and simulation, and equipment and tool design is one of the technical competencies which most companies would like graduates to be able to apply their knowledge to real-world problems and situations.

At the University of Northern Iowa, tool design is a required course for industrial technology program with manufacturing and automation option. This class has been designed to help the student achieve the following objectives: (a) acquire the theoretical and practical knowledge required to develop, design, and select tooling that will produce manufactured products economically, reliably and quickly; (b) develop communication skills with respect to the ability to define a project, support choices made in the decision stage, and clearly communicate the parameters of a design to the professor, and (c) improve student ability to self-learn (Hall, 1999). Modular fixturing concepts is one of the areas that instructors have introduced in tool design class.

The main purpose of this chapter was to identify related literature and discuss research on the trends in manufacturing of modular fixturing concepts, theoretical basic for automating fixture design fundamentals, CAI, computerized multimedia tutorials, and ITS development as it relates to the proposed development of this research. The literature reviewed here begins by providing three topics which are discussed below: (a) trends in modular fixturing systems; (b) automated fixturing design fundamentals; (c) computerized tutorial program development; and (d) group experimental designs as methods of teaching subject in industrial technology curriculum.

Trends in Modular Fixturing Systems

According to Mr. Edward G. Hoffman (1991), the basic concept of modular fixturing was first developed in the early 1940s. The person credited with developing the first workable modular tooling system was Mr. John Warton. Mr. Warton presented the idea of modular tooling to the British government during the early stages of World War II. Working under the commission of the War Department, he helped establish the first modular tooling system at the Bristol Aero Company, outside Bristol, England.

Another early innovator of modular tooling concepts was R. H. Rich. Mr. Rich, worked with Mr. Walton to develop many of the various components used for modular tooling. After the war, Mr. Rich brought the system to the United States and was awarded first American patent for this type of tooling system that was granted in 1949. Since then, there have been many other individuals and companies, who have improved on the concept by adding a wider variety of components and increasing the versatility of the systems. However, the basic concept of a workholding system with modular, interchangeable parts has remained largely unchanged.

Currently, modular fixturing systems can be used with several applications such as vertical and horizontal machining centers, EDMs, CMMs, and robotic assemblies. Mechanical components that can be used with modular fixturing include value body, bearing block, gear box and chuck jaws (Carr Lane Manufacturing Co., 1991).

At Great Bend Manufacturing Company, Mr. Dave Schneider, Engineering Manager reported that the firm installed precision fixturing tables with modular fixtures as one of several approaches that improved the quality of their product line while reducing overall costs. Using this concept, the firm manufactured 20 separate models of front-end-loader attachments for farm tractors. These required 600 different mounting-bracket arrangements to suit the various tractor styles and models (Welding Design and Fabrication, 1998).

Automated Fixturing Design Fundamentals

Traditionally, fixtures have been designed and manufactured as a single device for a specific part. The traditional approach is costly due to the very long lead-time and effort required to design and manufacture specific purpose fixtures. These factors have motivated researchers to develop software for automating fixture design and setup. An important requirement of an automated fixturing system is the ability to provide verification of the fixture during the design stage (Trappey & Liu, 1992). According to Shirinzadeh (1996), fixture verification is an integrated part of the design process and must allow for detection of an inference that may occur during the fixture construction.

Cabadaj (1990) proposed theoretical aspects of the computer aided fixture design in intelligent manufacturing systems. All aspects of the tasks are oriented to the three following parts: design of the function model, evaluation of the function model and creation of the fixture documentation. In the first part is the relation between the workpiece and the fixture elements. The second part of the design process is an evaluation and a selection of alternative solutions. The third and last design phase is creating the fixture documentation.

In fixture design activities of manufacturing systems, there are three steps: setup planning, fixture planning and fixture configuration design (Rong & Bai, 1997). The objective of setup planning is to determine the number of setups needed, the orientation of workpiece, and the machining surfaces in each setup. Setup planning has been addressed in the framework of CAPP (Joneja & Chang, 1989). Fixture planning is used to determine the locating, supporting, and clamping points on workpiece surfaces. The purpose of fixture configuration design is to select fixture elements and place them into a final configuration to locate and clamp the workpiece.

Research on setup planning was presented by Rong and Bai (1996). In that research paper, analysis of machining errors with different setup planning has been developed for fixture design verifications, where the dependency of resultant dimension variations on the variations of relevant dimensions are investigated including linear and angular dimensions. Five basic dimension relationship models of locating datum and machining surfaces are given to estimate the machining error under different setup conditions. A datum machining surface relationship graph (DMG) was developed to construct a tolerance chain analysis. A matrix representation and reasoning algorithm were developed to automatically search and evaluate the dimension relationship of the datum and machining surface.

A prototype of a feature-based fixture planning system has been developed for preparing the fixture clamping position and orientation of the base part (Liou & Suen, 1992). The system used a composite of elementary features (geometric and nongeometric properties of fixtures and workpieces). A fixture process planning system was implemented using a knowledge base so the fixturing plan can be modeled and optimized through the facts extracted from the fixture attributes and auxiliary principles. A rating technique for feasibility evaluation can offer a reasonable approach to include all the active facts into an optimal solution. Through this analysis, a product can be evaluated for its manufacturability, cost, and cycle time at the product design stage.

Commercially available modular fixturing systems typically include a lattice of holes with precise spacing and an assortment of precision locating and clamping modules that can be rigidly attached to the lattice. Currently, machinists manually design a suitable arrangement of these modules to hold a given part. This requires expertise and can delay production (Brost & Goldberg, 1996). Moreover, a machinist may in many cases settle upon an arrangement that is not optimal for a given machining operation (Personal communication with Paul Stern, 2001). Brost and Goldberg (1996) presented an implemented algorithm that accepts a polygonal description of the part form, and efficiently constructs the set of all feasible fixture designs that kinematically constrain the part in the plane. Each fixture was comprised of three locators rigidly attached to the lattice and one sliding clamp, and constrains the part without relying on friction. The algorithm was based on an efficient enumeration of admissible designs that exploited part geometry and a graphical force analysis. The algorithm run time was linear in the number of designs found, which was bounded by a polynomial in the number of part edges and the part's maximal diameter in lattice units. The algorithm was not consider out-of-plane forces or motions; however, Brost and Goldberg (1996) viewed this planar result as an essential component of a larger algorithm that solves the 3-D fixture design problem by treating the planar and out-of-plane constraint problems separately. This approach was analogous to the widely used 3-2-1 fixture design heuristic, and appears to be applicable to a broad class of man-made parts.

Penev (1997) developed a method for automatic design of modular fixtures. It consisted of determining which fixturing modules to select, how to set their parameters, how to compose them in functional units, and where to place them so that the result is a workholding setup adequate for the given workpart and manufacturing operation. The process of designing a fixture was decomposed into three consecutive phases: analysis, contact placement and layout design. Penev (1997) proposed to use areas of repulsion and attraction on the workpart boundary as a universal means of representing fixturing information. The algorithm simulated a potential field defined by these areas and performs a series of relaxation epochs of initially random configurations of contacts. Each contact was regarded as a charged particle that repels the other contacts within a certain distance. Starting with a minimal configuration, the number of contacts was subsequently increased if a certain number of epochs are unsuccessful. Thus, a solution will be found for any part. The simplicity of the potential field method allowed for a very efficient implementation. Experiments with a 2D implementation resulted in consistent success in time well below one second. The 3D algorithm performs in times of the order of several seconds on a conventional workstation.

In the context of on-going research in automating fixture configuration design, Wu, Rong, Ma, and LeClair (1998) presented their fundamental study of automated fixture planning with a focus on geometric analysis. The initial conditions for modular fixture assembly were established together with geometric relationships between fixture component and the workpiece to be analyzed. One-way to speed fixture design in a CAD environment is to utilize electronic catalogs of tooling and fixturing parts (Mason, 1995). All-American Products, San Fernando, California has recently introduced a CAD library with a Windows interface and graphic-oriented searching. The library contains thousand of tooling components, clamps, and accessories in 3D-wireframe database.

Computerized Tutorial Program Development

As computer technology with which to implement innovations become available, the techniques used to make instruction and learning more suitable for individuals have become more complex. Individualized work schedules have most recently been affected through the use of CAI, multimedia software and ITS which have been the focus of many studies.

CAI and Computerized Multimedia Tutorial

The term CAI (Computer Aided Instruction) has many definitions suggested by educators which are consistent with one another. CAI is a category of educational software that refers to lessons written for educational purposes using computer technology. All tutorial, computer-based (drill and practice) and simulation lessons can be referred to as CAI (David & Budòff, 1986). The use of CAI to support engineering and technology classroom instructions has been a major issue for many studies.

A concept of CAI was applied to construct a computer aided tutoring program which would provide deeper knowledge of engineering mechanics (Gaji & Kleiber, 1990; Ray, Yih, & Hopkins, 1990). Statics is one of the engineering courses that focuses on problem solving. With a CAI program, students can develop the art of visualization, the formulation and solution of the problem and the interpretation of their results. Students can resolve problems defined in such a way that their answer is not unique. Another advantage of this tutoring program is to make it possible for the student to correct and improve already existing designs that are purposefully misconceived and confused.

Ahmed Rubaai (1994) developed a computer-assisted instruction of power transformer design for undergraduate power engineering classes. The computer program was developed for the purpose of illustrating the design procedure of a single-phase transformer and demonstrating how it works. The objective was to meet all performance requirements at minimum cost. Students were provided with a computer analysis program to assist them in performing the routine calculations and, most importantly, optimize their designs.

Another tutorial presented in 1997 was the graphic-interactive system. This system was developed at the University of California at Berkeley (Krueger & Lieu, 1997). Their goal was to build a multimedia tutorial for a freshmen engineering graphic course. The topics covered the principles of orthographic projection, sectioning in engineering drawings, geometric dimensioning and tolerancing, and descriptive geometry. This tutorial employed the tools provided by multimedia to support 3D visualization through animation, focusing the user on graphics rather than text through audio narration, and promoting learning by association through interactive user interface.

C-book is another example of a CAI developed by Issac Herskowitz (2000). C-book is a computer aided teaching tool (CAT) for instructors of the C programming language. The tool provides graphics and animation allowing the instructor to visualize selected complex lecture concepts. The rational of the C-book development project design is to respond to the following needs:

1. To present complex programming problems in order for them to be easily learned.

2. To provide materials with alternative representations as a response to different learning styles.

3. To present, in a pedagogically sound way, a programming language whose design parameters do not include teachability.

Intelligence Tutoring System (ITS)

A wide variety of ITS have been designed specifically for teaching technical classes. Some have developed simulated systems designed to take the place of a helper or assistant in the learning process.

Chu, Mitchell, and Jones (1995) proposed and articulated a set of requirements for a ITS. The requirements specify what (instructional content) and how (instructional strategies) to teach a novice operator to supervise and control a complex dynamic system. The instructional content teaches system structure and behavior (i.e., declarative knowledge), system procedures (i.e., procedural knowledge), and how to use this declarative and procedural knowledge to manage a complex dynamic system in real time (i.e., operational skill). GT-VITA (Georgia Tech Visual and Inspectable Tutor and Assistant) realizes these requirements. As a proof-of-concept demonstration, an instance of the generic GT-VITA tutoring architecture was implemented for satellite ground controllers. The empirical evaluation, utilizing NASA satellite ground control personnel, showed that GT-VITA was a flexible and useful training system. In fact, NASA has adopted VITA as the foundation for required training for all satellite ground control personnel.

Yoshikawa, Shintani, and Ohba (1992) developed an ITS called "circuit exerciser." This system is designed to help university students in an engineering program learn more about electric circuits. It can formulate drill problems, solve them, and infer mistakes in a student's answer. It can also provide helpful comments to the student on how the mistake was made. The system shows the circuit of the presented problem on graphic displays and is student-friendly.

The engineering tutor is another example of ITS (built by Corrado Poli in the College of Engineering, University of Massachusetts) and focuses on visualization (Woolf, 1996). The engineering tutor teaches the concepts of design for manufacturability (DFM), specifically design for injection molding, to first-year engineering students. It allows the user to create and manipulate models of injection molded plastic parts within a constrained 3 dimensional (3D) CAD environment. The student can engage in exploration/part creation given several constraints, request general help, and ask for tutor comments.

Group Experimental Designs as Methods of Assessing Knowledge

Many researchers in a technical area such as industrial technology have made use of group experimental designs when comparison involves at least two groups. A selected experimental design directs to a great extent the specific procedures of a study. L. R. Gay (1996) discusses about types of group design selection in this way,

> Selection of a given design dictates such factors as whether there will be a control group, whether subjects will be randomly assigned to groups, whether each group will be pretested, and how resulting data will be analyzed. Depending upon the particular combination of such factors represented, different designs are appropriate for testing different types of hypotheses, and designs vary widely in the degree to which they control the various threats to internal and external validity. (p. 360)

Farn-Shing Chen (1995) developed a computer tutorial and simulation system for teaching digital function minimization. This study was designed to compare student achievement resulting from learning minimization of Boolean algebra by computer tutorial versus traditional lecture/practice instruction (manipulation actual components). Two groups of undergraduate students participated in this study and were randomly assigned to either the experimental or control group. A pretest was giving to both groups. Four hours were used to teach the control group the concepts and theories of minimization of Boolean functions by lecture, and another four hours were used to conduct laboratory experiments using the actual electronic components. On the other hand, the experimental group utilizes the computer tutorial and a simulation program for eight hours. Then the posttest was administered to all subjects to measure knowledge of minimization of Boolean functions. The analysis of covariance (ANCOVA) was used to analyze the data. A “2 x 2” ANCOVA was used to compare the adjusted results of the control and experimental group’s score, the differences due to sections, and the interaction of groups and sections. The findings of the study revealed that there were no significant differences between the computer tutorial/simulation program and lecture/practice methods, but the average time spent for the computer tutorial/simulation program in the experiment group was much less as compared to the control group.

Daniel G. Wilson (1994) investigated the relationships between student learning style (aptitude) and student outcomes with CAI (treatment). CAI software on light and color theory was validated and administered to undergraduate student in an educational media course at University of Northern Iowa. Participant in the study was first asked to complete the Grasha-Riechmann Student Learning Style Scales (GRSLSS) inventory along with a demographic survey. Next, each participant completed a pretest, engaged in the CAI, and completed a posttest. Student achievement with CAI was defined as gain scores, a measure of the difference between pretest and posttest scores. Finally, attitude toward CAI was measured through the use of Allen's Attitude Toward CAI Instrument, a semantic differential tool. A stepwise multiple regression analysis suggested that learning style as measured by the GRSLSS is an inadequate predictor of either student achievement with CAI or student attitude toward CAI. There was no significant relationship was found between attitude toward CAI and gain scores. This finding suggests that significant learning occurs regardless of student attitude toward CAI. It was concluded that learning style, as measured by the GRSLSS, is an inadequate measure of factors related to aptitude for CAI. Other possible reasons for finding no effect include: (a) the sample of students participated as volunteers, and (b) the sample consisted of teacher education majors, schooled in instructional design and media.

Ali E. Kashef (1990) studied a comparison of effectiveness between computer aided drafting and the traditional drafting techniques as methods of teaching pictorial and multiview visualization. The purpose of this study was to contribute to an understanding of the relative effectiveness of two different methods of teaching multiview and pictorial drawing. The subjects for this study were the full and part time undergraduate students in industrial technology at Montclair State College. One section was assigned randomly to a CAD group and the other one assigned randomly to a traditional group. A quasi-experimental design of the nonequivalent control group was utilized for the study. Each section was pre-tested and post-tested. The data were analyzed using the t test, Pearson correlation coefficient and transformation of r to Fisher's Z. The t test was used to compare group mean scores on Differential Aptitude Tests-Space Relations (DAT-SR) and visualization tests and to compare the amount of time needed to complete various parts of the visualization test. Pearson r and Fisher's Z was used to compare the difference between two independent correlations. Six hypotheses were tested at the .05 level of significance. There was no significant difference in score or in the amount of time required to identify pictorial equivalents of given multiview drawings on a visualization test between students who were instructed in beginning technical drafting using CAD and those instructed using traditional drafting methods.

Gary S. Godfrey (1999) investigated the student's behavior in achievement of test score if three-dimensional computer aided modeling methods are used when teaching cognitive spatial visualization skills. Three intact classes of engineering graphics and two intact classes of technical drawing in a college of engineering at the university level were assigned to either the control or experimental groups. Both control and experimental groups received identical lectures. The control groups completed two-dimensional computer-aided design laboratory assignments. The experimental groups completed three-dimensional computer-aided modeling laboratory assignments. The treatment phase was for one term (16 weeks). The Purdue Spatial-Visualization Test/Visualization of Rotations was used for evaluation purposes. This test was used as Pretest (Week 1), Posttest I (Week 9), and a Posttest II (Week 16). Each group's ability in cognitive spatial visualization was analyzed for its level of significance using the t test for independent means or one-way analysis of variance. The findings indicated that there were no significant differences between the three-dimensional and two-dimensional groups' performance at the first week ($p = .319$), ninth week $p = .638$), and 16th week ($p = .079$) intervals. The findings indicated that there was a significant ($p = .028$) difference between the two-dimensional strong and two-dimensional weak background experience groups' performance at the Week 1 interval. The two-dimensional strong background experience group performed at a higher level. There were no significant (p = .303) differences between the groups' performance at the eight-week interval. There was a significant difference (p = .022) between the three-dimensional weak and two-dimensional strong background experience groups at the 16th-week interval. The two-dimensional strong background experience group performed at a higher level. These findings should encourage teachers to incorporate and use three-dimensional methods of instruction

CHAPTER III

METHODS AND PROCEDURES

This chapter describes the experimental research design that used a quantitative model to examine the effects of computerized multimedia tutorial programs for learning concepts of modular fixturing design. A two-group comparison was conducted (control and experimental). In this chapter, the overview of the experimental research design is described at the beginning, followed by the description of the population and sample, location, limiting conditions, sampling technique, procedures, materials, variable of the study, hypothesis of the study, and statistical methods.

Overview of the Experimental Research Design

This study was involved with two groups of University of Northern Iowa students at the baccalaureate level. The control group in this study was a group of students who enrolled in tool design class as their interest, elective course and requirement for graduation. In addition, seven volunteers were added to the control group due to the limited number of students in the actual class. The experimental group was randomly selected from a group of students enrolled in the Manufacturing Technology, Electro Mechanical System, General Industry & Technology and Technology Education programs in the Department of Industrial Technology. The contents of this instructional module are as follows:

1. Basic concepts and principles of modular fixturing.

2. Modular fixturing components: mounting plate (grid holes and dowel systems), mounting plate (t-slot systems), mounting accessories, locators, and clamps.

3. Modular fixturing implementation for a specific machining.

The control group was instructed via the lecture method while the experimental group used a computerized multimedia tutorial program.

Pre-Requisite Knowledge

All students who participated in this study had a background on fundamentals of manufacturing process, technical drawing, or a similar class where they were exposed to the basic concepts of tooling and engineering drawing. In other words, students who enrolled tool design class must have fulfilled the following prerequisite courses unless instructor has waived pre-requisite:

330:008: Materials and Processes of Manufacturing

330:024: Technical Drawing and Design I

330:170: Statics and Strength of Materials

330:172: Industrial Materials

Location

The experiment took place in the Department of Industrial Technology at the University of Northern Iowa. Two laboratories were used: a computer laboratory located in the Industrial Technology Center (ITC) building, room 24, and a computer laboratory located in room 19.

Limiting Conditions

This study was limited by the following factors:

1. Only students enrolled in Tool Design class during spring 2000 semester participated in the control group (use of intact class).

2. Only students with a declared major in Manufacturing Technology, Electro

Mechanical System, General Industry & Technology and Technology Education program during spring of 2001 semester were randomly selected to participate in the experimental group.

3. Only 15 students in the control group were available to participate in this study.

4. Only 15 students in the experimental group were available to participate in this study.

5. This study was limited to selected laboratory and classroom activities.

6. The control group was limited to instruction provided by one experienced instructor (Mr. Roger Woock, Manufacturing Engineer and Tooling Expert).

7. Two graduate-teaching assistants were selected to administer the computer tutorial program to the experimental group.

8. The textbook used in this study was Fundamental of Tool Design (Society of Manufacturing Engineers, 1998) with additional materials provided from instructor.

9. It was necessary to administer the treatments (control group versus experimental group) one-year apart.

10. Control of instruction content for the control group was limited to informal discussion between the researcher and the designated instructor. Difference in mean score may be the result of variability in module content between the control group and the experiment group.

Sampling Technique

The population of this study was comprised of the students who enrolled in the Manufacturing Technology, Electro Mechanical System, General Industry & Technology and Technology Education programs at the University of Northern Iowa during the spring of 2000 and 2001 semester. The samples from the population for this study were 15 students enrolled in the experimental group and another 15 students enrolled in the control group (due to a limited number of students in Tool Design class during spring of 2000 semester, 7 volunteer students were added to the control group).

Although some authorities suggested that 30 subjects per group should be considered minimum, Gay (1996) and Kashef (1990) recommend a minimum of 15 subjects per group for experimental studies. A priori power estimation is complicated in situation like this, where little previous research is available to permit estimation of effect magnitude. However, after some deliberation (personal communication with Dr. Andrew R. Gilpin, May, 2001) it was presumed that the use of a repeated measurers design would allow detection of moderate effects with 15 participants in each group (in fact, the significant results reported suggest that this was a reasonable assumption).

Procedures

The research schedule is shown in both Table 1 and Table 2. The experimental phase of the study was implemented during the seventh though ninth week of a 16-week semester. Both groups were instructed on the same basic topics covered in this study.

For the control group, the general course content for this research study was discussed with Mr. Roger Woock before a pretest was administered in the seventh week of tool design class during the spring 2000 semester. A copy of pretest and posttest were given to Mr. Roger Woock which helped him to better present the same content and terminology as the treatment group. During the eighth week, 3 hours were used to teach the control group the concept of modular fixturing design by lecture. During the ninth week, a posttest was administered to all subjects to measure the knowledge gained of modular fixturing design concepts.

On the other hand, an experimental group utilized the computer tutorial program for 3 hours during the spring 2001 semester (after completing the pretest in the seventh week). During the ninth week, a posttest was administered to all subjects to measure knowledge gained of modular fixturing design concepts.

An Interactive Computerized Multimedia Tutorial Development

An interactive multimedia tutorial, entitled ToolTRAIN, was developed by the researcher (author) explaining the process of modular fixturing design concepts. The program was developed using a four phase instructional design process (Wilson, 1994) and consisted of a needs assessment, the design of instructional content, the production and evaluation of the software, and the validation of the computer tutorial program.

Table 1

Time Schedule of the Research Design for Control Group (spring 2000 semester)

Week	Activities
7th week	Pretest (1 hour)
8th week	Lecture (3 hours)
9th week	Posttest (1 hour)

Table 2

Time Schedule of the Research Design for Experimental Group (spring 2001 semester)

Week	Activities
7th week	Pretest (1 hour)
8th week	Computer Tutorial (3 hours)
9th week	Posttest (1 hour)

The first phase in the development of the computer tutorial software process was to complete a needs assessment. This assessment included an analysis of the learners for which the instruction was intended. During the second phase of development the instruction was designed through a storyboard technique. This technique allowed the researcher to visualize a wide variety of solutions to instructional problems. The order of the instructional steps was selected and the script for instructional delivery written. The third phase of development involved the production of the software. In this step, the program was flowcharted and authoring of the software was carried out. Table 3 shows a list of the software packages and the purpose of using them to develop ToolTRIAN. A discussion of the key feature software package follows.

Authorware® 5.1 is a very comprehensive authoring software package intended for users with full commitment to creating multimedia-tutoring systems. Authorware's basic operating style allows the user to create an interactive production by drawing flowchart like diagrams whose interconnected icons control how the project plays back (see Figure 1). Some icons cause the project to branch to different areas depending on user choices. Users can incorporate text, graphics, sound, animation and video from a number of complementary programs. Authorware's interactions include multiple-choice and fill-in-the-blank questions, matching exercises, clickable "hot spots," and drag-and-drop activities. These interactions can be designed to test a user's knowledge and programmed to react differently based on the user's response (Cullen, 2001). When created properly, a standard Authorware program can be run on both Windows and Macintosh operating systems without the need for a special player. With these capabilities, Authorware® 5.1 was the primary software architecture and mechanism behind ToolTRIAN.

Table 3

List of Software Packages

Software	Purpose
Macromedia Authorware® 5.1	Authoring System
Pro/ENGINEER® 2000i2	Solid Modeling
3D Studio MAX® R3	Animation
Adobe Photoshop® 5.5	Digital Illustration
Adobe Premiere® 5.1	Video Editing
Goldwave® 4.02	Sound Editing

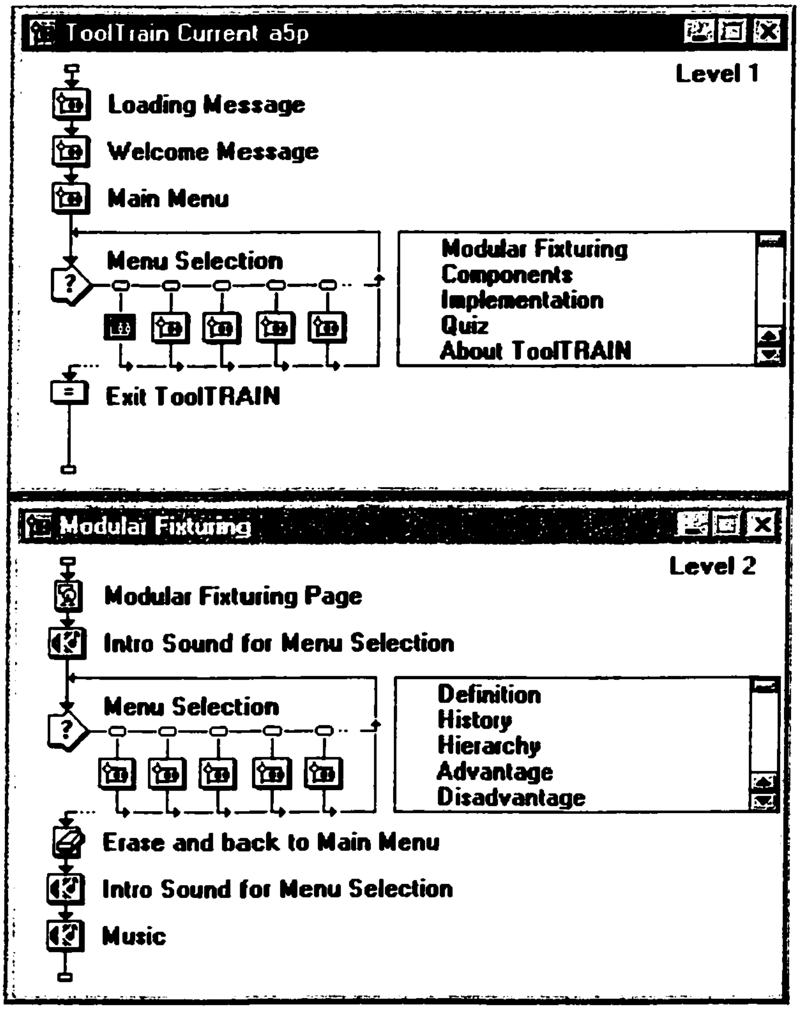

Figure 1. Interconnected icon control in Authorware®'s environment.

Pro/ENGINEER® 2000i². A fully parametric based solid modeling software product, Pro/ENGINEER® uses feature-based modeling to create a part. This means the designer creates all the features that make up that part. Typically, the designer begins with a base feature, which is a solid object roughly the shape of the part he/she wants to create. Then, the designer can add features (cuts, slots, holes, chamfers, and other features) that shape the base object into the part. With Pro/ENGINEER®, it is possible to examine the final part in a number of ways including wireframe, hidden line, and shaded versions. In this research, the researcher utilizing this package created all of modular fixturing components that show in ToolTRAIN (see Figure 2). Pro/ENGINEER® 2000i² also provides different formats for exporting a file to the different application software packages.

3D Studio MAX® R3. This was the professional 3D modeling, animation and rendering software for creating visual effects, character animation and next generation game development. 3D Studio MAX ® R3 delivers a fully collaborative 3D environment and new high-speed interactive rendering. With completely customizable and extensible architecture, it allows for absolute artistic freedom. 3D Studio MAX ® R3 supports the largest third-party integrated application developer community of any 3D application. In ToolTRAIN, 3D Studio MAX ® R3 was used to create an animation of several modular fixturing systems (see Figure 3). All of the solid models (modular fixturing components) were imported from Pro/ENGINEER with a STL (Sterolithography) format. This format allows all of data to be transmitted into different type of 3D solid modeling software.

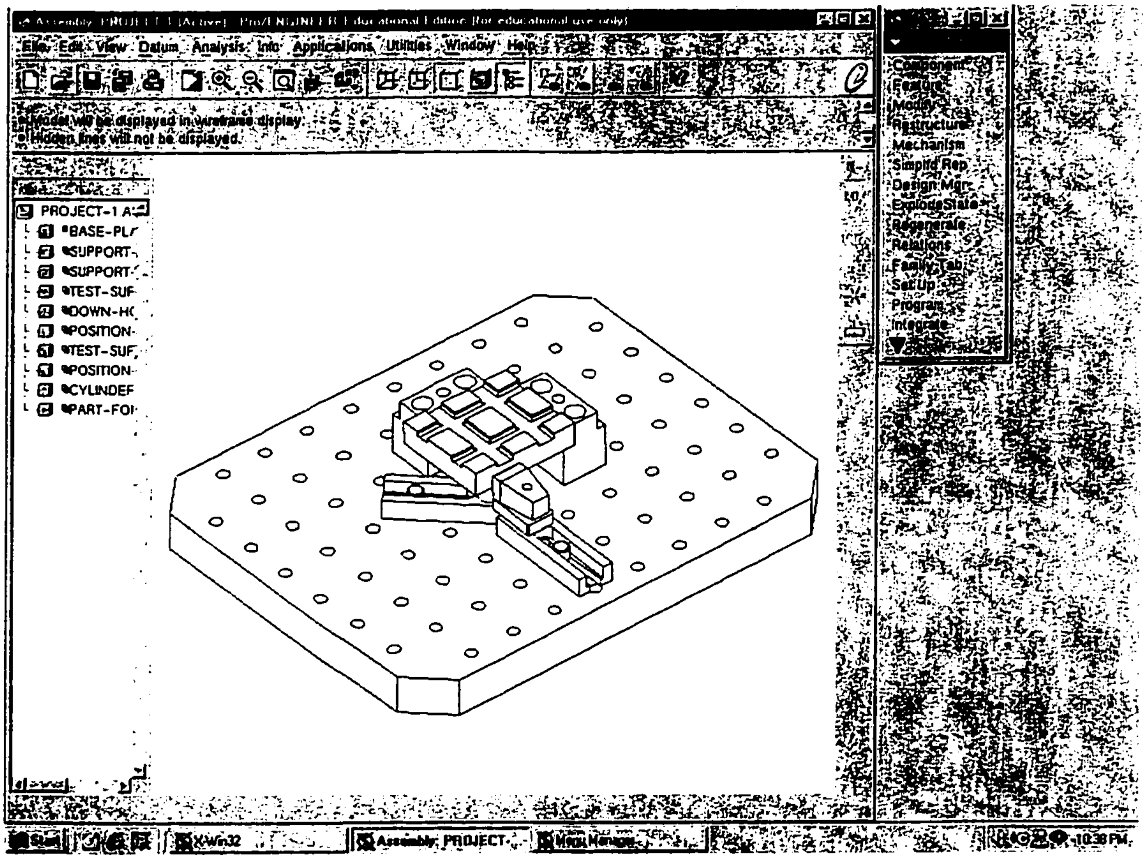

Figure 2. Pro/ENGINEER® 2000i^2 screen and interface with assembly of modular fixturing components.

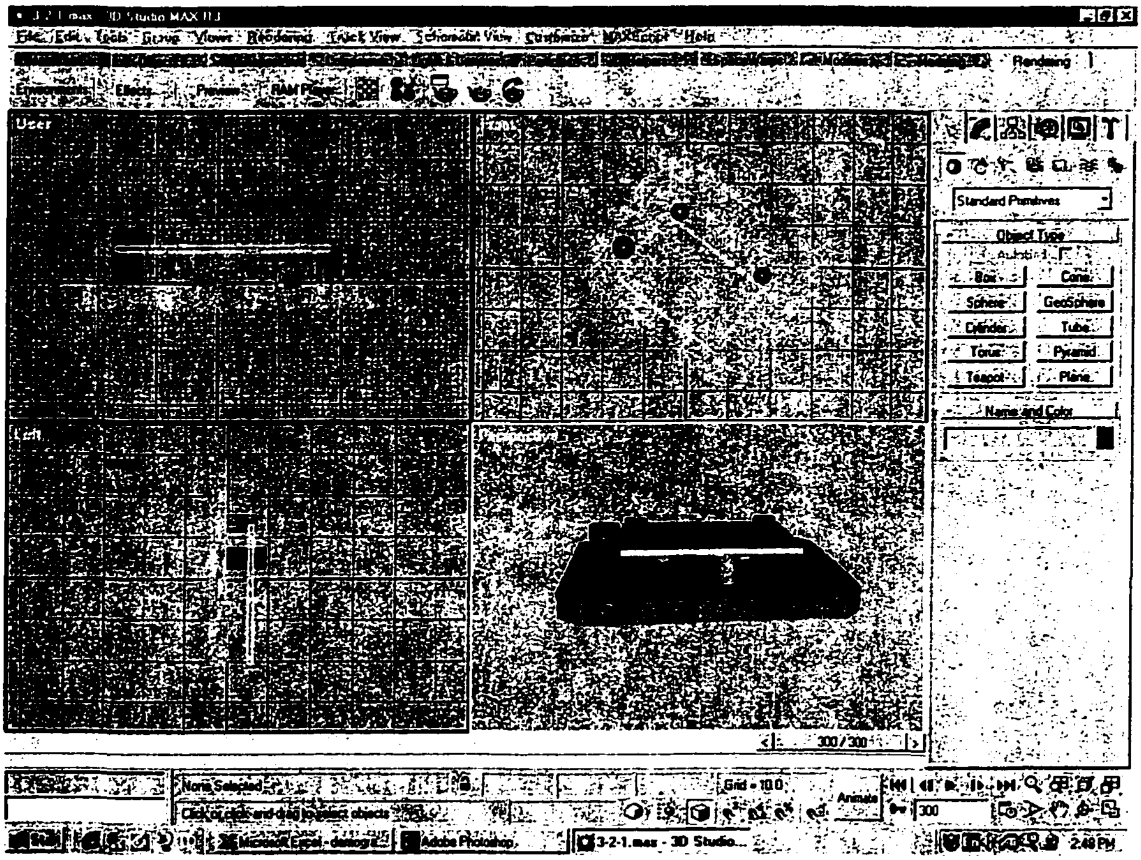

Figure 3. 3D Studio MAX® R3 screen and interface with modular fixturing components.

Adobe Photoshop® 5. This software combines powerful image-editing capabilities with a useful interface. It is easy for users to utilize. Several digital illustrations in ToolTRAIN benefit from Photoshop's features, such as modes, options, and special layers. Most tools have customization settings to determine how quickly the system can perform and what aspects of the image system modify. Figure 4 shows the working environment under Adobe Photoshop® 5.

Adobe Premiere® 5.1. This software is a great tool to edit video. Adobe Premiere® 5.1 remains the power user's video editor of choice. This product is a traditional editor in which separate windows provide access to a multitrack timeline, previews, transitions, trimming functions, and a clip library. Tools such as ripple and rolling edits, multiple-track selection, and the jog, shuttle, and play commands in the clip window make it possible to edit large amounts of image on film very quickly. The researcher took advantage of these features to edit several video clips that appear in ToolTRAIN. Figure 5 illustrates a working environment under Adobe Premiere® 5.1.

Goldwave® 4.02. This is a comprehensive digital audio editor. It contains many great features such as play, edit, mix, and analyze audio. Goldwave® 4.02 was used to edit all of digital audio parts in ToolTRAIN development process. Figure 6 shows a working environment under Goldwave® 4.02.

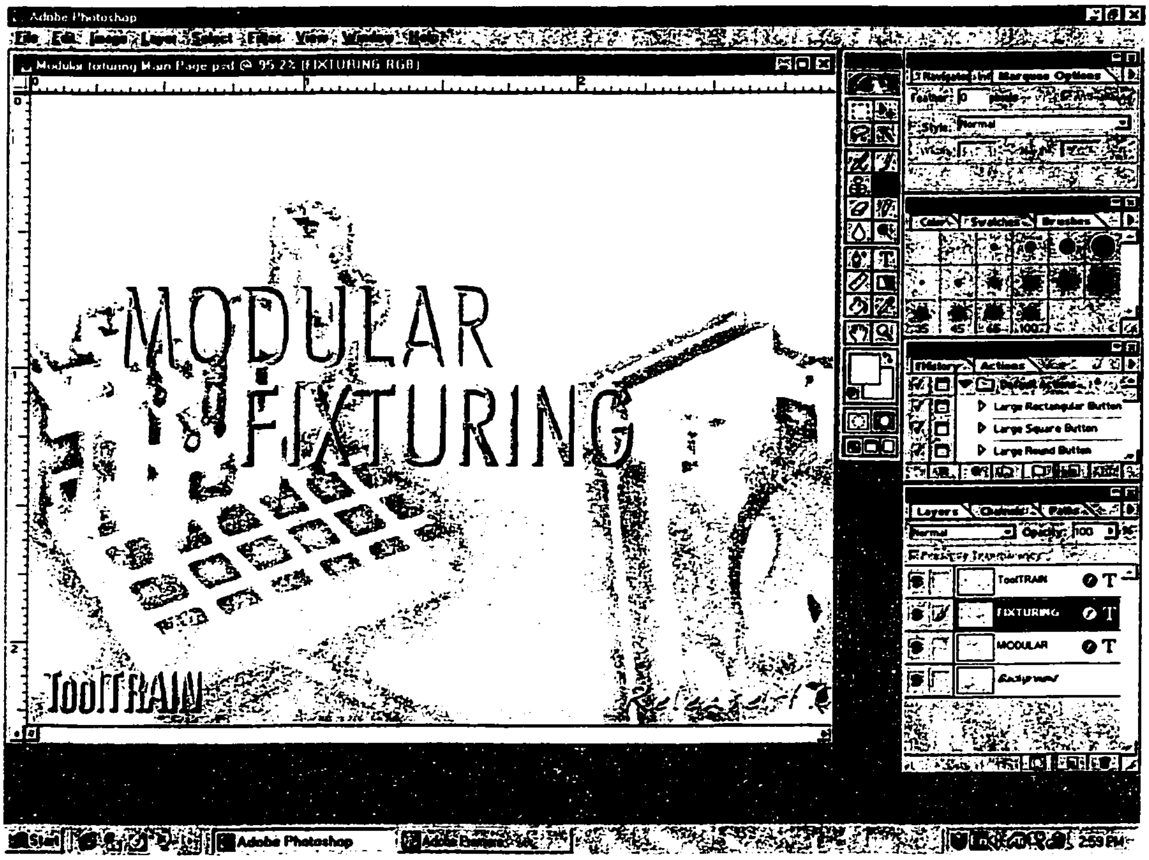

Figure 4. Adobe Photoshop® 5 screen and interface with a sample of digital illustration.

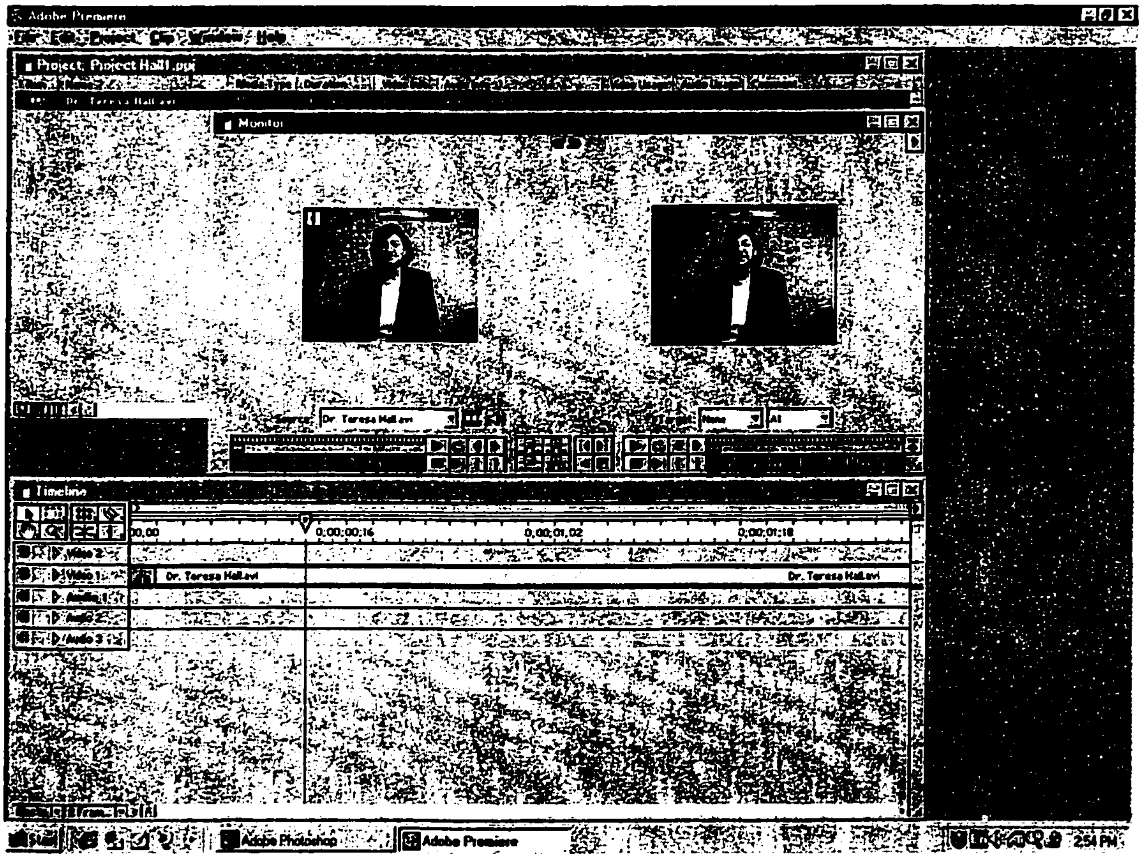

Figure 5. Adobe Premiere® 5.1 screen and interface with a sample of video editing.

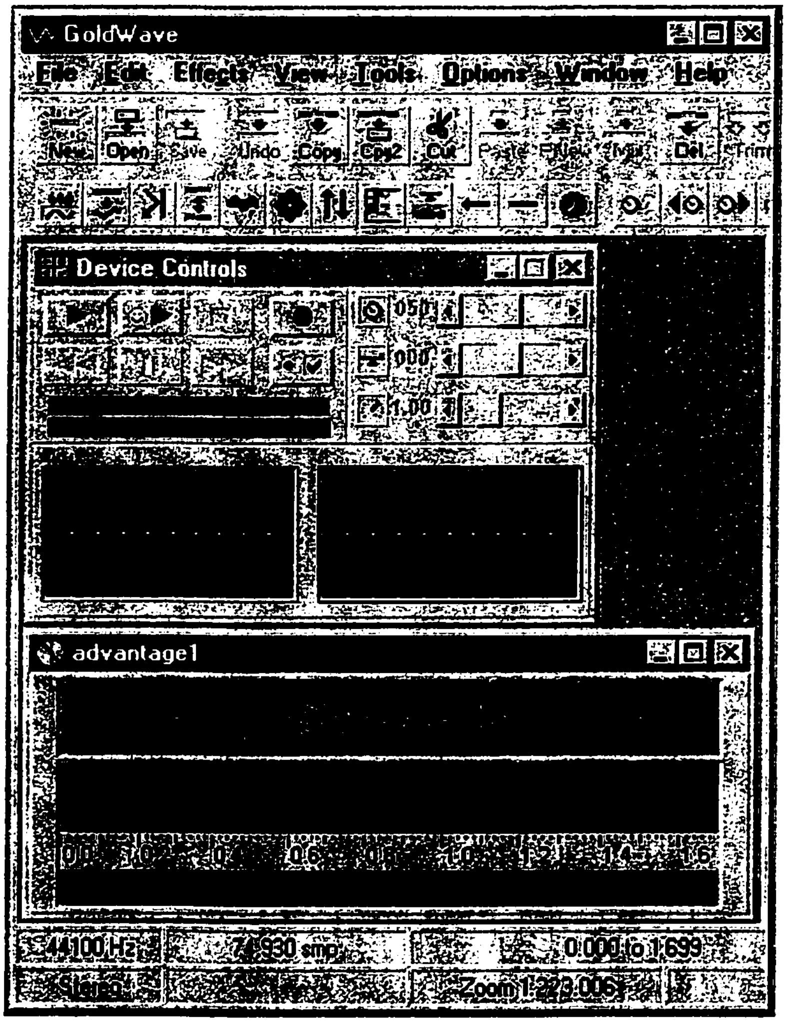

Figure 6. Goldwave® 4.02 screen and interface with a sample of audio editing.

Tutorial Testing and Validation

Once the initial software was completed, the developer completed a formative evaluation by asking 10 people from both industry and higher education to use the software tutorial and report to the researcher with critical remarks. The resulting criticisms were used to guide revision of the software. In the last phase of development, ToolTRAIN was examined by a panel of content experts whose names are listed in Appendix I. These experts rated the accuracy of the content and the appropriateness of the software tutorial program for college students. On a rating scale of 1 (poor) to 9 (excellent), the experts' mean rating of the software yielded a score of 7 (see Table 4).

Table 4

Validity Ratings of the ToolTRAIN on a Scale of 1 to 9

Expert	Software Rating
1	9
2	7
3	9
4	8
5	6
6	7
M	7.66

ToolTRAIN Release 4

After several trial versions, ToolTRAIN version 4 (called release 4) was finally released with full multimedia capabilities. The experimental group used the latest release. ToolTRAIN software requires the following systems (recommended requirements): (a) Minimum Pentium II class processor (or 100% compatible), (b) 64 MB RAM (128 MB RAM recommend), (c) 200 MB hard drive space for installation, (d) 16 bit sound-card and speakers, and CD-ROM drive (32X or faster), and (e) 8 MB RAM Open GL video card (16 MB RAM recommend) with a minimum of 1024 × 768 screen resolution. A hierarchy diagram of tutorial content is shown in Figure 7. There are four main units in the instruction system and they are (a) Modular Fixturing, (b) Components; (c) Implementation, and (d) Quiz. A main page is shown when the student enters into ToolTRAIN (see Figure 8).

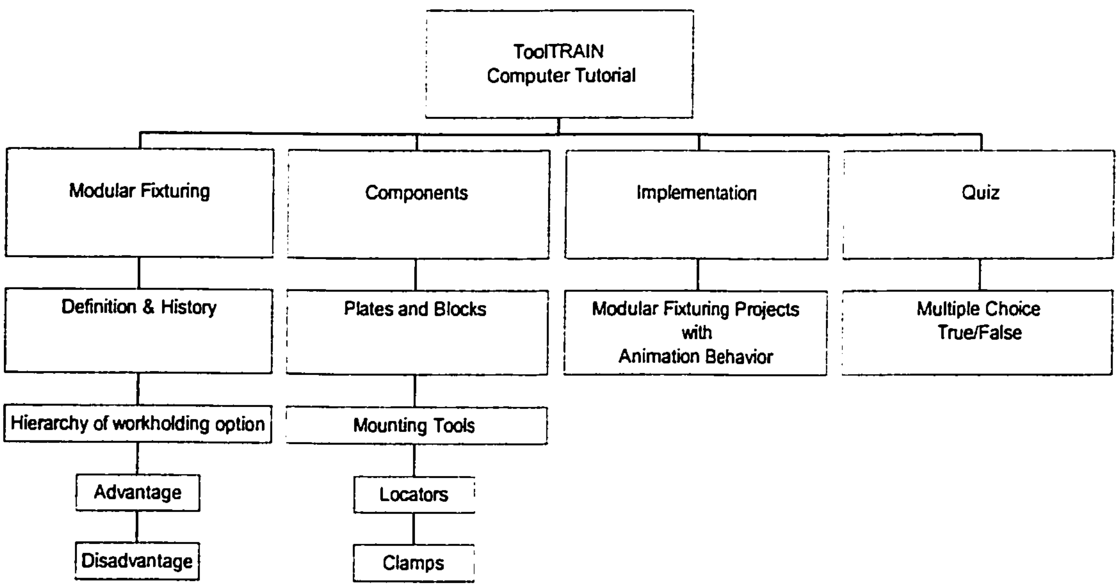

Figure 7. Hierarchy diagram of tutorial content.

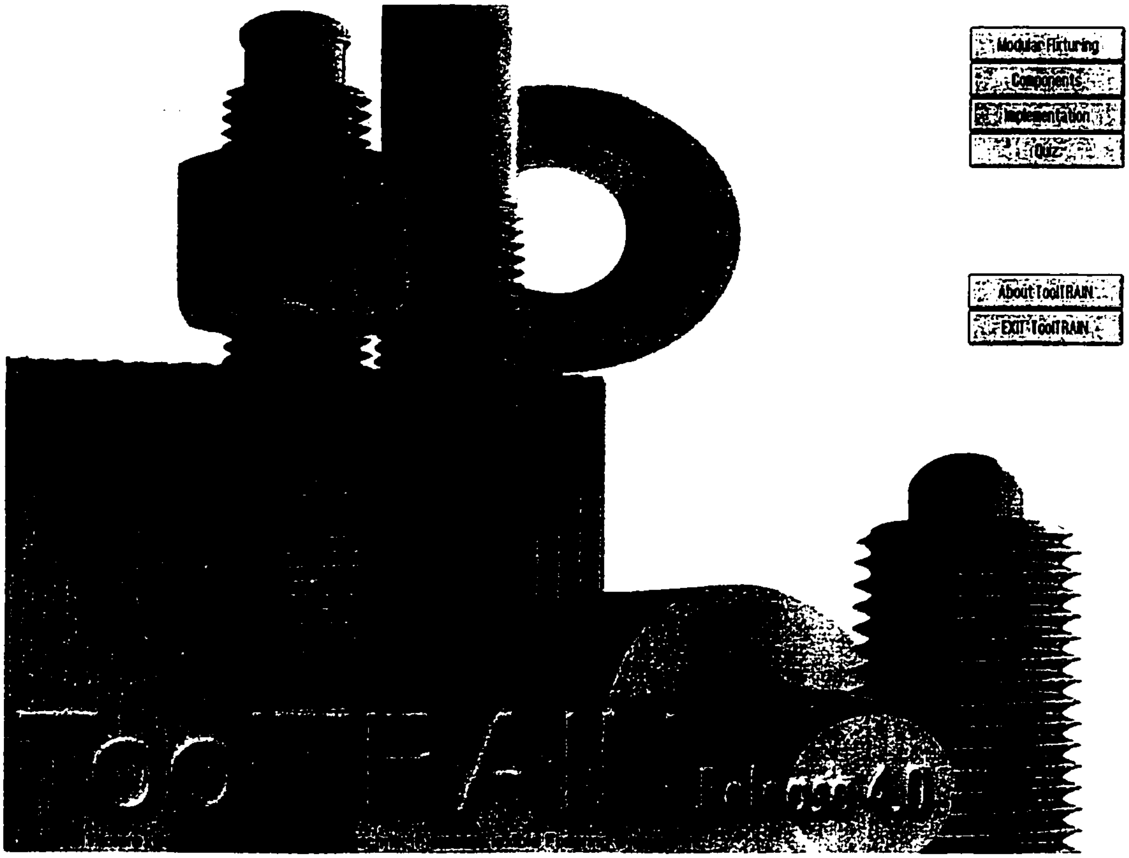

Figure 8. ToolTRAIN main page.

<u>Modular fixturing unit</u>. The modular fixturing unit provides some definition, historical perspective, hierarchy of workholders, and briefly shows the advantages and disadvantages of using modular fixturing. Figure 9 shows the main screen of the modular fixturing unit. The modular fixturing unit includes a video clip from a tool design professor who shares an alternative idea for a modular fixturing concept. This video clip appears on the sub-screen of the modular fixturing unit (see Figure 10).

<u>Components unit.</u> This unit presents the fundamentals of modular fixturing components. The components unit also provides information on grid holes vs. t-slots forms. Four main basic components of modular fixturing are introduced: (a) tooling plates and blocks, (b) mounting accessories, (c) locators, and (d) clamps. Figure 11 shows an example of the first screen of the tutorial (locators unit). Figure 12 also shows an example of the tutorial under locators unit.

<u>Implementation unit</u>. The implementation unit introduces a student with rules and methods to simplify modular fixturing functions. Similar to the modular fixturing unit, a video clip of one industrial technology professor speaking about the 3-2-1 concept was added to this unit (see Figure 13). In addition, this unit contains four projects that demonstrate how several modular fixturing components can be assembled with a wide variety of workpieces. The researcher took advantages of using this capability by presenting information in a graphical manner such as 3D visualization through animation, making it easy for students to understand the concept of modular fixturing (Figure 14 and 15).

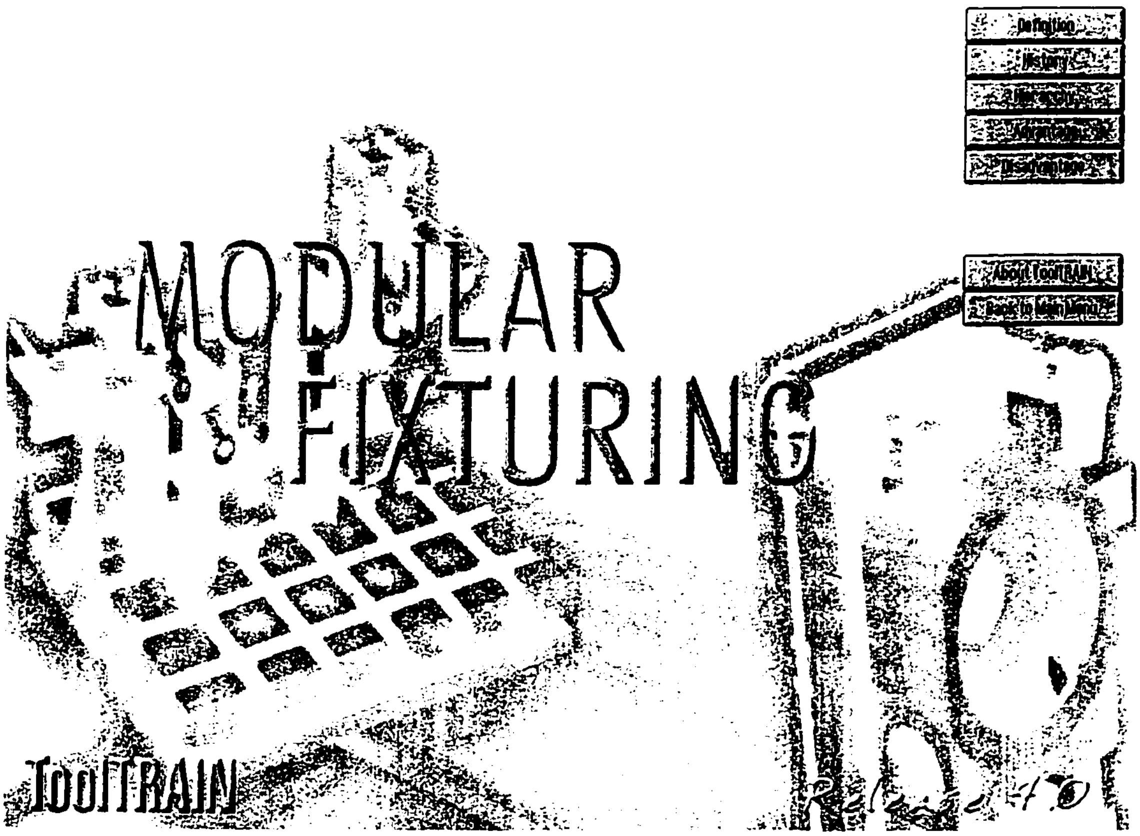

Figure 9. ToolTRAIN's modular fixturing unit main page.

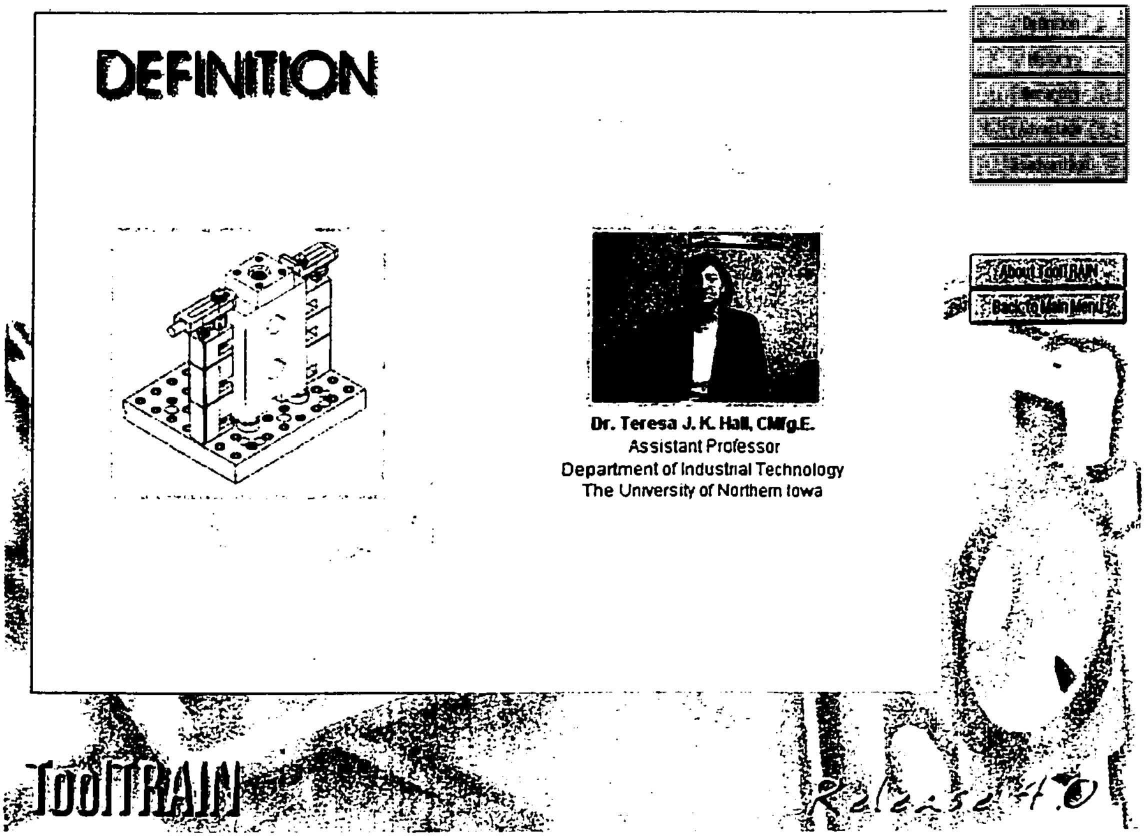

Figure 10. Video clip shows on sub-screen under modular fixturing unit.

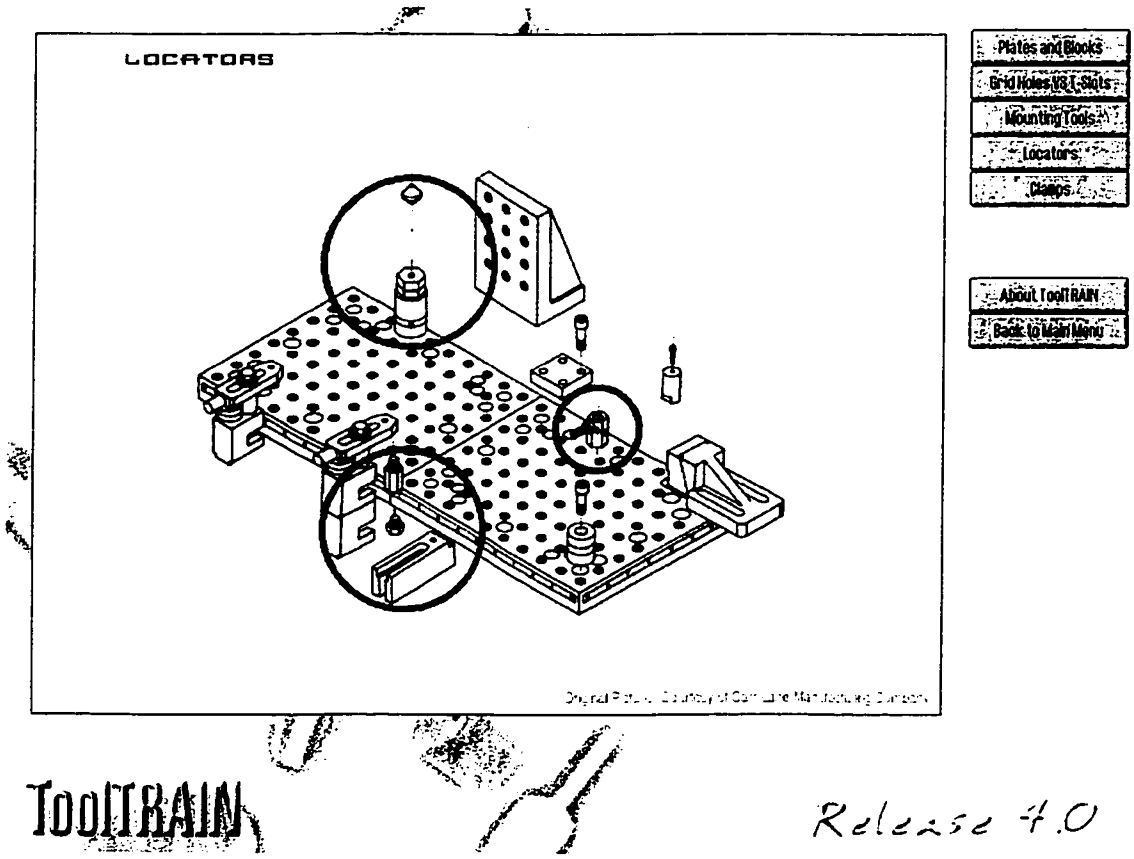

Figure 11. Example of beginning tutorial screen procedure under component unit.

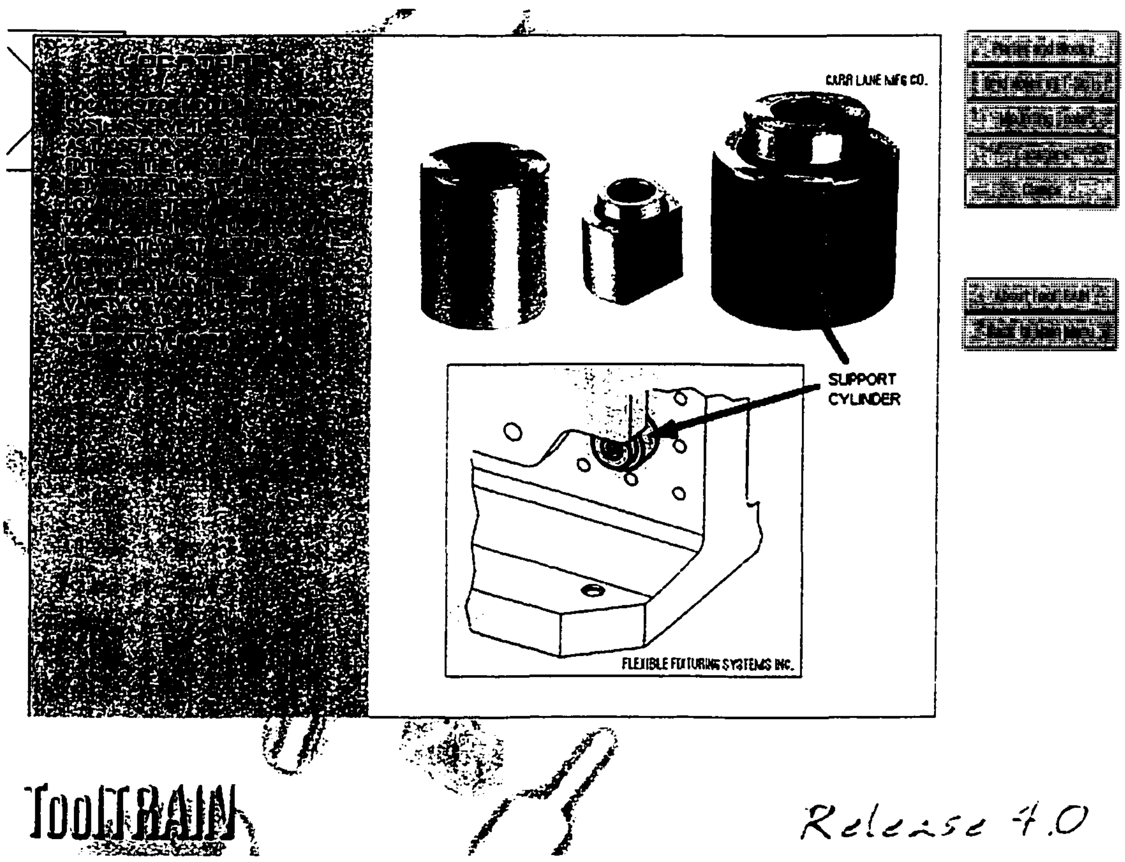

Figure 12. Example of tutorial screen shows under component unit.

Figure 13. Video clip shows on sub-screen in the implementation unit

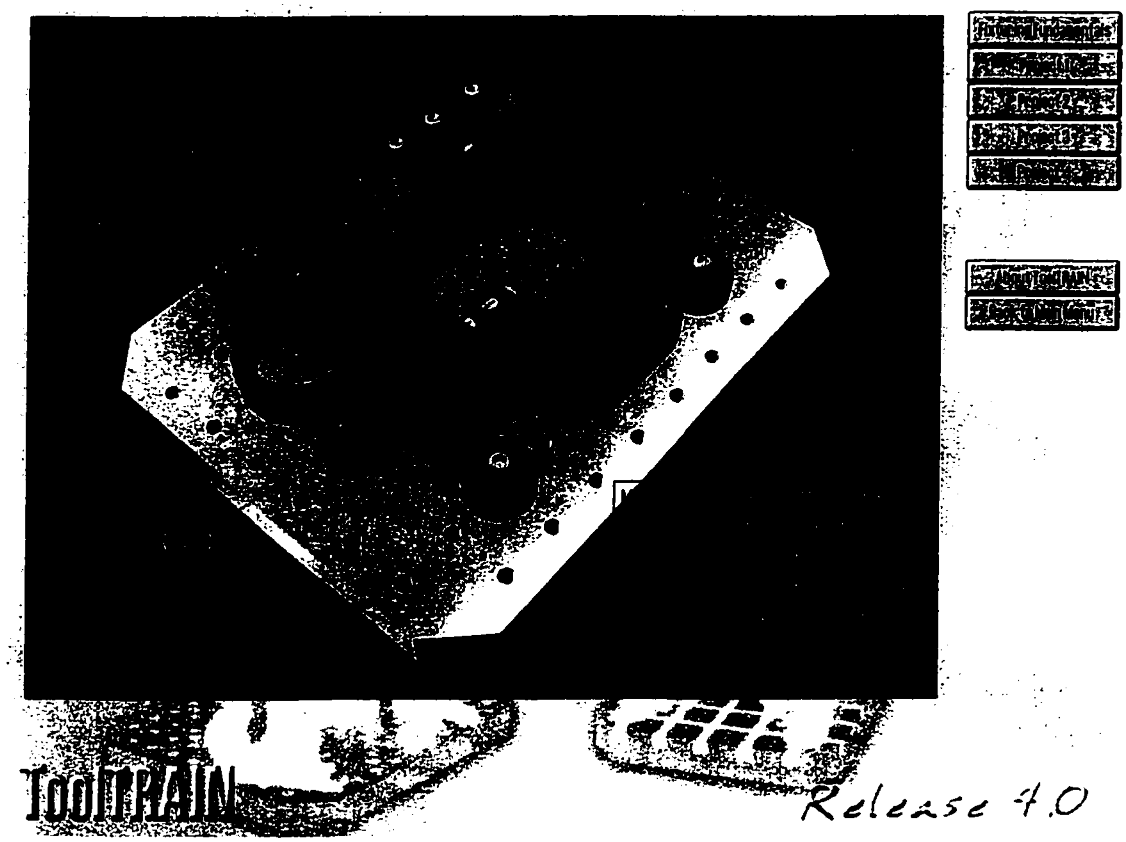

Figure 14. Example of modular fixturing project in the implementation unit (3D visualization with animation feature).

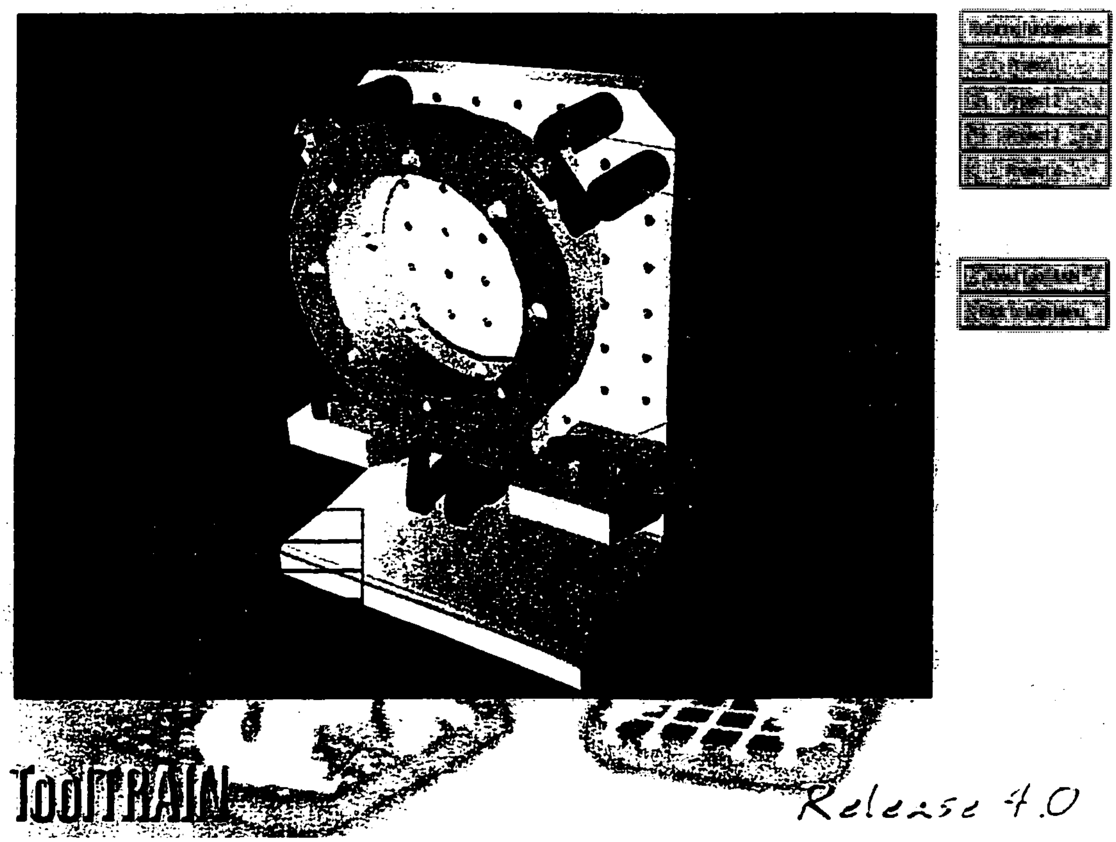

Figure 15. Example of modular fixturing project in the implementation unit (3D visualization with animation feature).

Quiz unit. The last unit of ToolTRAIN is a quiz unit where responses are multiple choices and true/false. This unit allows students to test their knowledge of the material just covered. ToolTRAIN gives the student an opportunity to try again or to review the lesson where the necessary information is discussed. Figure 16 illustrates an example of multiple choice questions in ToolTRAIN.

Features of ToolTRAIN

In ToolTRAIN, simplicity, compatibility, and interactivity were the major factors in shaping the design. Interactivity was incorporated by giving the user full control over the system. Simplicity was a major concern in ToolTRAIN. All possible efforts were made to try to produce a system that is easy to use. It was assumed that menu pick would create a reasonable level of interactivity. Users can just click on the menu items in order to move the next screen. Users can also differentiate between a regular mouse move and menu pick by noticing that the mouse shape will change to a different icon (arrow to hand symbol). Screen lay out is a key component of successful design. If information is not presented in a pleasant and easy to follow format, then users will be reluctant to use the system. An important concern is how much information should be placed on the screen.

In a personal communication from Dr. Ali E. Kashef (February, 2000), he stated that the screen should be organized into areas according to functionality by dividing the screen into sub-windows. Each sub-window represents an independent entity. In ToolTRAIN, there are different screens involved in the design. The screen skeleton was designed based on functional organization.

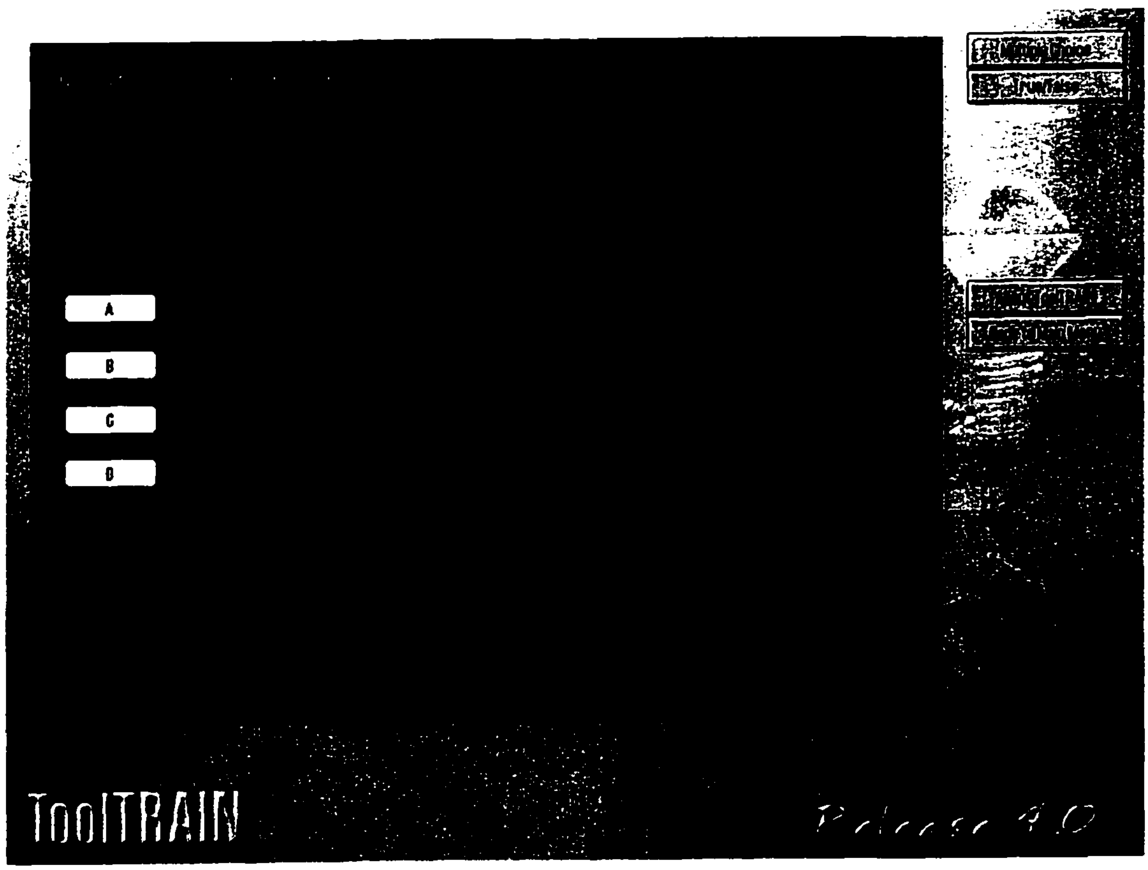

Figure 16. **Multiple choice question in the quiz unit.**

The main screen (or main menu) consists of four units: modular fixturing, components, implementation, and quiz. These units are grouped according to their functionality. Each unit is a major unit for any concept of modular fixturing system, therefore expandability was one of the objectives in the design of the screen. Expandability means that any additional data can be developed and added to ToolTRAIN any time.

ToolTRAIN's User Interface.

Human computer interfaces are important because it is through these that instructional dialog is constructed. However, while the role of the user interface is often regarded from the point of view of user system performance, it is less frequently considered from the perspective of user learning. The focus of user interface development has been changed from monitoring issues to cognitive issues centered on learning. The goal in developing interactive multimedia is not to make computers more powerful, but to make users more productive. The user interface of ToolTRAIN is designed based on the concept of menu-based interaction.

According to Newman and Lamming (1995), menu-based interaction is the user interface that presents the user with a display of options, and the selection of an option may generate a further set of options. In another words, menu-based interaction provides a means for inexperienced users to navigate through extensive system functionality, using simple forms of technology.

The functions provided by the ToolTRAIN user interface (menu picks) show up to the right corner of each page, with commands arranged vertically. As users move the mouse pointer up and down within command menus, a small-hand symbol under pointer appears at the same time. The symbol ensures that users selected the right choices. This prevents the user from issuing an inappropriate or unavailable command. The sub-screen will appear after users picked the menu interface prior to the tutorial begin the training process. The architecture of this user interface is comprehensive and linked to the submenu in each unit of tutorial (Figure 17).

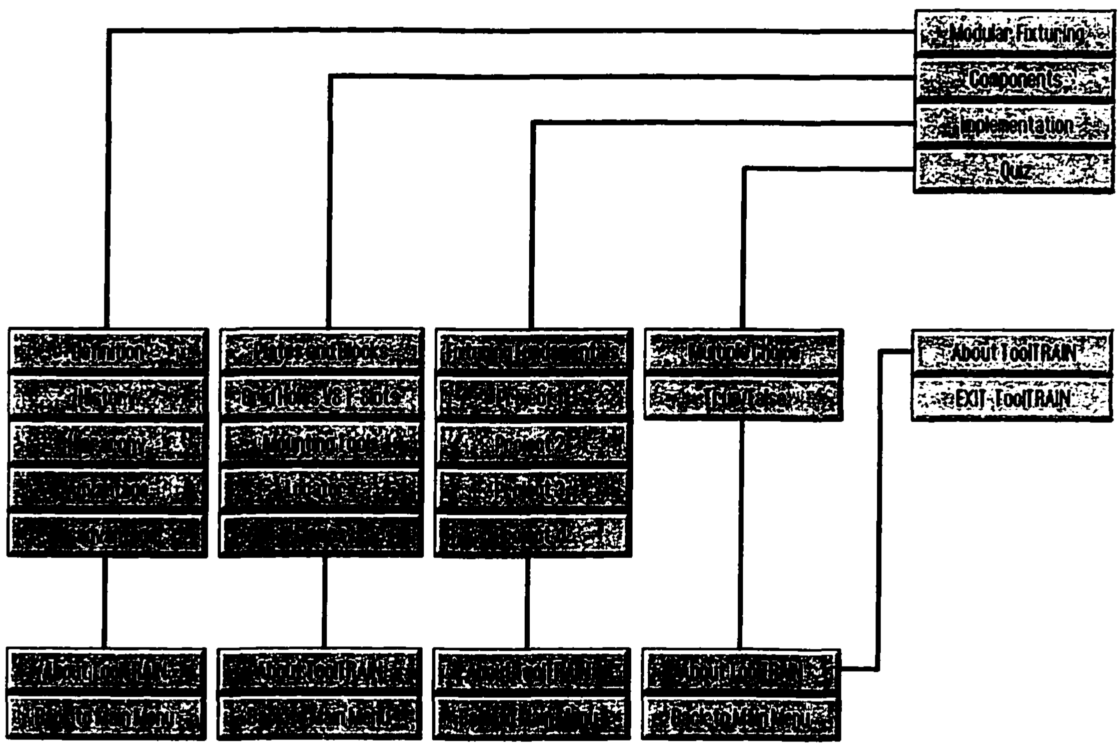

Figure 17. Architecture of ToolTRAIN's user interface

Data Collection Instruments

Pretest and posttest instruments were designed to measure a student's knowledge regarding to the concept of modular fixturing design. These instruments were used to collect data pertinent to this study. They are the following:

1. The pretest and posttest consist of 25 multiple-choice items. Six items were developed to measure knowledge of basic concepts and principles of modular fixturing theories; 12 items were developed to measure modular fixturing component knowledge; 7 items were developed to measure knowledge of modular fixturing implementation.

2. The content of the posttest was the same as that of the pretest except that the questions were reordered.

3. Change from pretest to posttest reflected whether students acquired knowledge of modular fixturing design during instruction.

4. No questions relating specifically to any computer software were posed to either group.

Validation of the instrument (computer tutorial, pretest and posttest) was established through a jury of experts (listed in Appendix I). To accomplish this, three industrial technology faculty, one mechanical designer and one information system analyst were contacted one semester prior to the experimental group was utilized the computer tutorial program. The jurors were given a briefing on the research study and were asked to (a) examine the instructional objectives, and to (b) use the computer tutorial program and test.

A form was given to the jurors asking them to rate the extent to which the comprehension evaluation measured the acquisition of knowledge as stated in the instructional objectives on a scale from 1 (poor) to 9 (excellent) See Appendix F. The jurors' mean rating on the comprehension evaluation test was 7.83 out of a possible 9 (see Table 5). These ratings suggest that the comprehension evaluation test has content validity. It also suggests that the computer tutorial program is accurate and therefore it is suitable for use in a college setting.

Table 5

Validity Ratings of the Pretest-Posttest on a Scale of 1 to 9

Expert	Test Rating
1	9
2	8
3	9
4	7
5	7
6	7
M	7.83

Demographic survey. There were several demographic factors examined in this study. These included each subject's (a) gender, (b) year in school, (c) level of experience with computers (self-reported), and (d) level of experience with computer tutorial (self-reported; see Appendix A).

Student evaluation. Given the objective of the software, it was hoped that the evaluation would support the effectiveness of this software tutorial (ToolTRAIN). Another aim was to get feedback on the various components of the software. This questionnaire was given to the students after they used the ToolTRAIN program (see Appendix H). All students answered the questionnaire without being able to re-access the ToolTRAIN program. Questions included in this questionnaire were divided into two categories: program evaluation as a learning enhancement tool, and user interface evaluation.

Effective courseware not only functions very well, but is also easy to use. Therefore, human computer interaction (HCI) is one of the issues that were covered in the experiment. It is clear that it is very hard to get a user interface that satisfies the tastes of every user; however, some degree of satisfaction is expected. Arranging information on the screen is also very important in learning. A good screen should have the minimum information that conveys maximum meaning to the user. This questionnaire asked students to react to the screen design and to moving back and forth between screens of ToolTRIAN. The last issue of interest was learning time. When a student accomplishes a certain job in less time, it can be concluded that the student has high cognitive skills (Airir, 1995; i.e. has the ability to learn fast).

Laboratory Equipment

The experimental group in this study used the following computers and software and hardware:

1. IBM compatible microcomputer with the following specifications: Pentium III 550 MHz, 128 MB RAM, 17" Standard Monitor, 16 MB Video Card (OpenGL) Build-in Sound Card, and Speakers.

2. Microsoft Windows 98.

3. ToolTRAIN Release 4 (developed by researcher).

Variables of the Study

The dependent variable in this study is the knowledge of modular fixturing which was represented by pretest and posttest scores. The primary independent variable is method of instruction (i.e., computer tutorial vs. traditional lecture).

A Quasi-Experimental Design

In a personal communication with Dr. Andrew R. Gilpin (January, 2000), he stated that in experimental research design sometimes is not possible to randomly assign subjects to groups. In order to receive permission to use college students in a study, a researcher has to agree to use existing classrooms. When this occurs, however, there are still a number of designs available to the researcher that provide some control of sources of invalidity. These designs are referred to as quasi-experimental designs (Gay, 1996).

A quasi-experimental design of the non-equivalent control group was utilized for this study. The symbolic modeling of this research design was designed as follows:

	X_1	
O_1		O_2
	X_2	

Where:

O_1 Pretest for the control and experimental group

O_2 Posttest for the control and experimental group

X_1 Treatment for the computer tutorial group

X_2 Treatment for the traditional group

Because of practical limitations, the two groups of students were necessarily fairly small. This concern, together with the use of a quasi-experimental approach with existing groups, suggests that individual difference in tool design knowledge existing before the study might confound results. To help address this problem, a repeated measures design was used, in which each subjects received a pretest of their knowledge; a second, post-manipulation administration of the same test assessed their knowledge at the end of the experiment. For each subject, a change score was computed (viz., the pretest score was subtracted from the posttest score). The resulting scores represent changes in knowledge, with positive values representing increases, and negative values representing decreases.

Statistical Methods

The three hypotheses predict that subjects in the experimental group should show change scores (posttest - pretest) which are at least as large as those obtained by subjects in the lecture group. This study was designed to test the following null hypotheses.

Null Hypotheses

Major null hypothesis. There is no significant difference between the general performance on test scores of students who used the computer tutorial and those who experienced traditional teaching methods.

Sub-null Hypothesis 1. There is no significant difference between the performance on knowledge test scores of basic concepts and principles of modular fixturing of students who used the computer tutorial and those who experienced traditional teaching methods.

Sub-null Hypothesis 2. There is no significant difference between the performance on knowledge test scores of modular fixturing components of students who used the computer tutorial and those who experienced traditional teaching methods.

Sub-null Hypothesis 3. There is no significant difference between the performance on knowledge test scores of modular fixturing implementation of students who used the computer tutorial and those who experienced traditional teaching methods.

To test each hypothesis, a separate independent groups t-test was computed comparing the change scores obtained by the computer tutorial group with those obtained by the lecture group. For each test, the null hypothesis was that there is no difference in the means of the two groups; the statistical alternative is that the means of the two groups are different in which case the direction of the difference was examined to determine which group showed more improvement.

CHAPTER IV

RESULTS AND DISCUSSIONS

The results of the data analysis are presented in this chapter. The primary purpose of this study was to determine if the computer tutorial program was an effective way of learning modular fixturing. The independent variable consisted of type of instruction: experimental (computer tutorial) vs. control group (traditional lecture). The dependent variable was cognitive knowledge gain. The test was administered twice, before and after instruction. These variables were used to examine the hypotheses presented in Chapter III. The purpose of the pretest was to estimate knowledge of modular fixturing prior to instruction. The post-test was intended to test knowledge of modular fixturing concepts after instruction. The test covered the three areas of modular fixturing (basic concepts, principle, components and implementation). This chapter is divided into three major parts. First, a presentation of demographic information on the sample is included to provide a profile of the subjects used for the study. Second, the results of the statistical tests on the hypotheses are reported and interpreted. Third, student evaluations are reported and discussed.

Demographic Information

Several demographic variables were assessed on the sample (see Appendix A). These included gender, year in school, level of experience with computers, and level of experience with an interactive computerized multimedia tutorial.

Gender of the Sample

The gender of the participants is presented in Table 6. The population of this study was comprised of the students who enrolled in the Manufacturing Technology, Electro Mechanical System, General Industry & Technology and Technology Education programs during the fall of 2000 semester at the University of Northern Iowa. The samples from the population for this study were 15 students enrolled in the experimental group and another 15 students enrolled in the control group (due to a number of students in Tool Design class during spring of 2000 semester, 7 volunteer students were added to the control group).

Table 6

Gender of the Sample

Gender	(n)	Percentage
Males	26	86 %
Females	4	14 %
Total Students	30	100 %

Year in School of the Sample

Most of the participants used in the study were juniors and seniors (see Table 7). The tool design course that the control group sample was derived from is a required course for the Manufacturing Technology major (not a general education course). The sample consisted of a variety of class levels, but included mostly seniors and juniors, only four sophomores and one freshman (in the experimental group) participated in the study.

Table 7

Year in School of the Sample

Gender	(n)	Percentage
Freshman	1	3.33 %
Sophomore	4	13.33 %
Junior	7	23.33 %
Senior	18	60 %
Total Students	30	100 %

Academic Majors

This study was involved with two groups of University of Northern Iowa students at the baccalaureate level. The control group in this study was a group of students who enrolled in tool design class as their interest, elective course and requirement for graduation. In addition, seven volunteers were added to the control group due to the limited number of student in the actual class. The experimental group was randomly selected from a group of students enrolled in the Manufacturing Technology, Electro-Mechanical System, General Industry & Technology and Technology Education programs in the department of Industrial Technology (see Table 8).

Table 8

Academic Majors

Majors	Control Group	Experimental Group
Manufacturing Technology		
Automated Manufacturing System	7	6
Design	3	2
Metal Casting	3	1
Electro Mechanical System		
Engineering Technology	0	0
Industrial Supervision & Management	0	1
General Industry & Technology	1	3
Technology Education	1	2
Total Students	15	15

Level of Computer Experience (Experimental Group)

Level of computer experience was measured on a five-point likert-type scale. The scale ranged from 1 to 5. Students were asked to rate their knowledge and experience with computers as either 1 (no knowledge and experience), 2 (little knowledge and experience), 3 (somewhat knowledgeable and experienced), 4 (fairly knowledgeable and experienced) or 5 (highly knowledgeable experienced). Overall, participants in the study (experimental group) rated themselves as having a medium to high level of computer experience (see Table 9).

Table 9

Self-Reported Level of Computer Experience (experimental group)

	Computer Experience (n = 15)
M	3
SD	1.07

Level of Interactive Computerized Multimedia Tutorial Experience (Experimental Group)

The subjects rated their level of experience on a scale from 1 to 5. Specifically, students in the experimental group were asked to rate their level of experience with computer tutorials as either 1 (no experience), 2 (little experience), 3 (somewhat experienced), 4 (fairly experienced), or 5 (highly experienced).

The level of previous interactive computerized multimedia tutorial experience reported by the subjects was unexpectedly high (see Table 9). Perhaps this reflects that the use of computer software tutorials has increased in educational institutions. It may specifically be due to an exposure to some other tutorial software within the Industrial Technology major at University of Northern Iowa. For example, experiences with computer tutorials are incorporated into the educational media course from which the sample came such as Graphic Interactive software (developed by Krueger and Lieu, 1997). Dr. Ali E. Kashef (May, 2001) stated that this software have been used as a supplement material for a Technical Drawing course at University of Northern Iowa for 6 years.

Table 10

Self-Reported Level of Interactive Computerized Multimedia Tutorial Experience (experimental group)

	Computer Experience (n = 15)
M	2.73
SD	1.16

Scores on the Knowledge Test

Subjects in both groups (experimental and control) took the knowledge test before and after the instruction. Change scores representing the post-instruction score minus the pre-instruction score were computed for each subject on items comprising the three content domains, and the overall scale. The mean and standard deviation for these change scores appear in Table 11. The means and standard deviations for the control and experimental groups in the area of basic concepts and principles of modular fixturing were 0.60 (1.18) and 2.27(1.10), respectively; for the area of modular fixturing components they were 1.53(2.29) and 3.67(2.61), respectively; for the area of modular fixturing implementation they were 0.33(1.72) and 3.67(2.61), respectively; and for the general performance (full scale or overall score) they were 2.47(2.47) and 8.20(3.59), respectively.

Hypothesis Testing

Three research hypotheses predicted that subjects in the experimental group (computer tutorial) would show change scores (posttest minus pretest) which were at least as large as those obtained by subjects in the control group (lecture group). This study was designed to test the corresponding null hypotheses.

Null Hypothesis

Major null hypothesis. There is no significant difference between the general performance on test scores of students who used the computer tutorial and those who experienced traditional teaching methods.

Table 11

Mean and Standard Deviations on the Difference in Score (change in score) Based on Four Areas of Knowledge

	Control			Experimental		
Areas	M	SD	n	M	SD	n
Basic Concept	0.60	1.18	15	2.27	1.10	15
Components	1.53	2.29	15	3.67	2.61	15
Implementation	0.33	1.72	15	2.27	1.58	15
Full Scale	2.47	2.47	15	8.20	3.59	15

Sub-null Hypothesis 1. There is no significant difference between the performance on knowledge test scores of basic concepts and principles of modular fixturing of students who used the computer tutorial and those who experienced traditional teaching methods.

Sub-null Hypothesis 2. There is no significant difference between the performance on knowledge test scores of modular fixturing components of students who used the computer tutorial and those who experienced traditional teaching methods.

Sub-null Hypothesis 3. There is no significant difference between the performance on knowledge test scores of modular fixturing implementation of students who used the computer tutorial and those who experienced traditional teaching methods.

The knowledge examination consisted of 25 multiple-choice items. Seven items were developed to measure knowledge of basic concepts and principles of modular fixturing theories; 8 items were developed to measure modular fixturing component knowledge; and 10 items were developed to measure knowledge of modular fixturing implementation. The content of the posttest was the same as that of the pretest except that the questions were reordered.

To test each hypothesis, a separate independent groups t-test was computed comparing the change scores obtained by the computer tutorial (i.e., the experimental) group with those obtained by the lecture (i.e., control) group. The resulting mean change scores appear in Table 10 as previously indicated. For each test, the null hypothesis is that there is no difference in the means of the two groups; the statistical alternative is that the means of the two groups are different (in which case the direction of the difference would be examined to determine which group showed more improvement). For the basic concepts and principles of modular fixturing scale, as predicted, there were significant differences between group means, $t(28) = -3.996$, $p < 0.001$ with the experimental group improving more. For the modular fixturing components scale, as predicted, there were significant differences between group means, $t(28) = -2.378$, $p < 0.05$, with the greater change in the experimental group. For the modular fixturing implementation scale, the change scores also showed that there were significant differences between group means, $t(28) = -3.208$, $p < 0.05$, again favoring the computer (experimental) group. Finally, for general performance on the test score (full scale), as predicted, the experimental group achieved significantly higher change in scores than the control group, $t(28) = -5.093$, $p < 0.001$.

Student Attitude Assessment of ToolTRAIN Software

The results of the attitudinal assessment are presented in Figures 18-27. The questionnaire was provided to the experimental group (15 students) after they completed the experiment (see Appendix H). The purpose was to obtain student opinions on the effectiveness of ToolTRAIN especially on the various components of the software. However, this evaluation procedure was not considered part of the primary experimental research.

Evaluation Questionnaire

Question 1: Would you like to see more of this kind of software tutorial in different classes?

This question was intended to test the general concept of accepting computer tutorial in classroom activity. It appears that students found the experiment very effective. The results showed that 93 % were in favor of using this kind of program in the next classroom activity. Most students explained their answer by adding that, it is quick and easy to learn modular fixturing concepts from the software tutorial. Figure 18 shows the frequencies of replies to Question 1 (need to see more of this software).

Question 2: Was it difficult to know how to operate the program?

This question covers one of the issues in human computer interaction. In this experiment, students were well satisfied with the ToolTRAIN interface (see Figure 19).

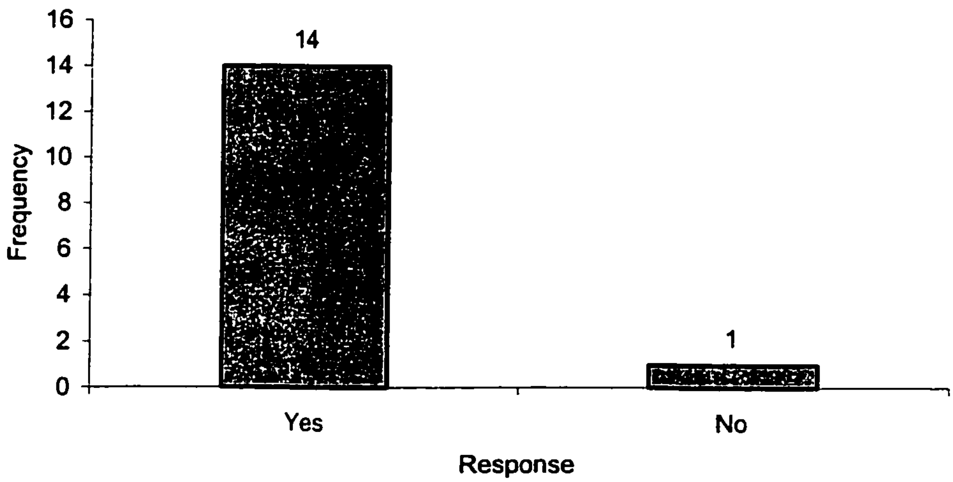

Figure 18. Frequencies of replies to Question 1.

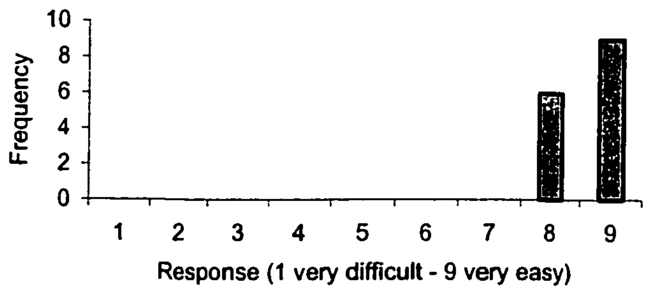

Figure 19. Frequencies of replies to Question 2.

Question 3: Was it difficult to remember the meaning of the commands to run the program?

It is important to get user views on their understanding of selection and icon representations. It is also important to design the display and select terms that can help students to remember what each icon does. The results (Figure 20) showed that most of students in the experimental group had no problem remembering the meaning of all the terms provided in the interface.

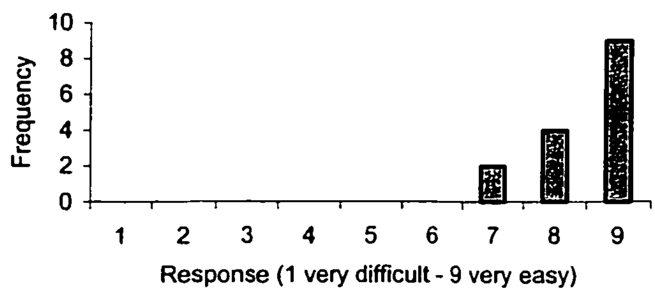

Figure 20. Frequencies of replies to Question 3.

Question 4: Was the layout of the screen helpful to understand how to use the program?

Arranging information on the screen is very important in learning. A good screen should have the minimum information that conveys maximum meaning to the user. This question was asked to determine how students react to the screen design. The result showed that there was a positive response to the question. Results of this question are shown in Figure 21.

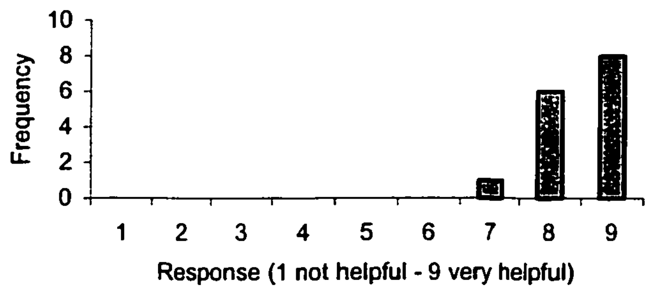

Figure 21. Frequencies of replies to Question 4.

Question 5: Did you feel comfortable with the color of the screen?

There is no doubt that color makes software more attractive, and conveys more information on process control information. For example, color is conventionally need to indicate all components and warning lights. However, the ultimate confirmation of this question is up to the user not the designer. Therefore, the question was intended to see how users felt about the color of the screen in the experiment. Again, results were acceptable. Most of students were comfortable with color used (see Figure 22).

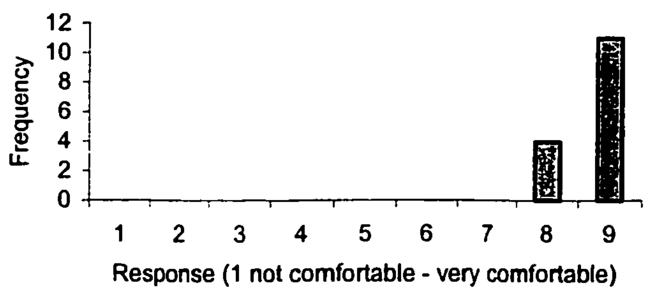

Figure 22. Frequencies of replies to Question 5.

Question 6: Is it easy to go back and forth between screens of the program?

When the information to be presented to the user is greater than the size of the display, paging is preferable compared to scrolling (Airir, 1995). However, paging could have disadvantages if the user gets lost between different screens. In ToolTRAIN, the researcher (developer) designed a sub-screen under each unit to eliminate this type of problem (see Figure 10-16). This question was presented to test if students have difficulties going between screens. Results are presented in Figure 23.

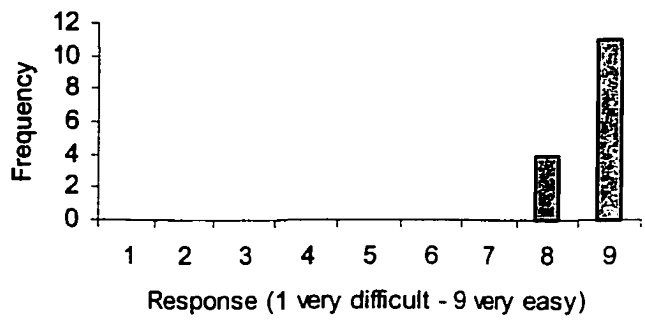

Figure 23. Frequencies of replies to Question 6.

Question 7: Were the terminology used throughout the system clear and meaningful?

Although ToolTRAIN is designed to employ a "menu picks" user interface, some concepts are difficult to represent in a graphical manner. Therefore, text and terminology were attached to each menu item. However, these terms themselves can be misleading in meaning; therefore this question was intended to get user assessment on the clarity of meaning of these terms. The result showed that the students had no trouble with the meaning of terminology (see Figure 24).

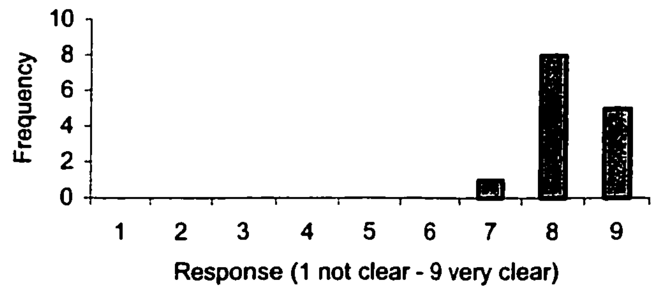

Figure 24. Frequencies of replies to Question 7.

Question 8: Are you satisfied with the way the information is arranged on the screen?

The arrangement of material on the screen plays a major role in locating information. This question was intended to test screen layout such as the subscreen in each unit, the position consistency, text, color, and screen background. Again the results were very positive; the students found that information was well organized on the screen. Figure 25 shows the answer of the students to this question.

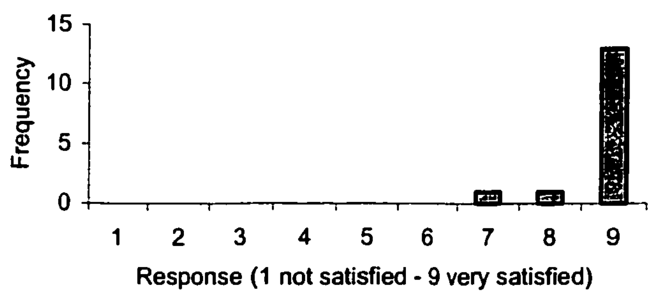

Figure 25. Frequencies of replies to Question 8.

Question 9: How would you rate ToolTRAIN software for the ease of use?

The ease of use reflects both the effectiveness and the efficiency of the interface and software. The range of the questions was given from 1 "very difficult" to 9 "very easy." All of the students, answer ranged between 8 and 9. The results clearly indicate that the interface was very effective and the system was very easy to use (see Figure 26).

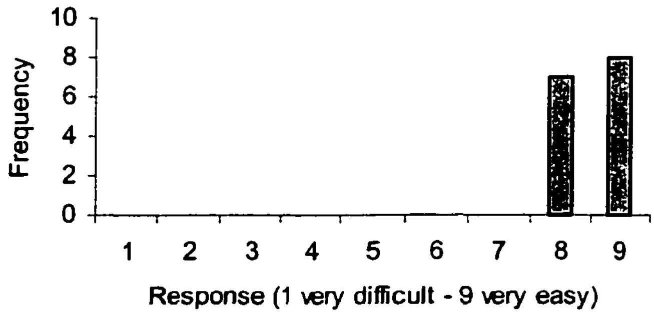

Figure 26. Frequencies of replies to Question 9.

Question 10: Were you satisfied with the time the experiment take using ToolTRAIN software?

Time is a critical issue in learning. When a student accomplishes a certain job in less time, it can be concluded that the student has high cognitive skills (i.e., has the ability to learn fast). ToolTRAIN reduced the lab time from 3 hours to 1 hour and 30 minutes on average. This question was presented to students so that they could give their opinion about the time the experiment took using the computer. The results in Figure 27 clearly indicate that the students were very satisfied with the time the experiment took.

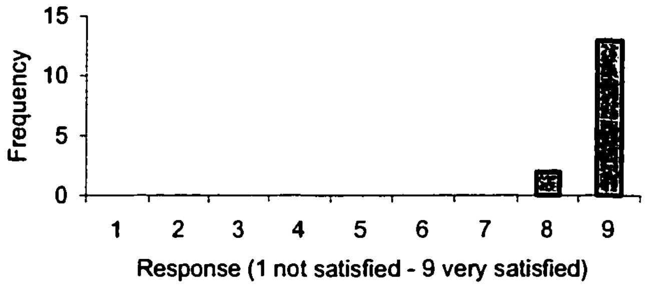

Figure 27. Frequencies of replies to Question 10.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter includes a brief summary of the problem as well as the research procedures followed. A discussion of the findings along with the conclusions and recommendations are also presented.

Summary

The purpose of this study was to develop and demonstrate the educational effectiveness of using an interactive computerized multimedia tutorial to teach a concept of modular fixture design at the undergraduate level, and to investigate whether two different instructional methods (traditional lecture vs. computer tutorial) are equally effective in teaching the concept of modular fixture design. The population of this study was comprised of the students who enrolled in the Manufacturing Technology, Electro Mechanical System, General Industry & Technology and Technology Education programs during the spring of 2000 and 2001 semester. The samples from the population for this study were 15 students assigned to the experimental group and another 15 students assigned to the control group. These students completed a pretest and posttest examination of knowledge of modular fixturing design, along with various instruments used to assess attitude toward computer tutorials and various demographic information. A summary of the findings related to the research hypotheses is described below.

Findings by Hypothesis

To test each hypothesis, a separate independent groups t-test was computed comparing the change scores obtained by the computer tutorial (i.e., the experimental) group with those obtained by the lecture (i.e., control) group. One major and three sub hypotheses were tested using the t-test statistical procedure. All the hypotheses were tested at the .05 level of significance. The results of the tests are summarized as follows.

Major null hypothesis. The purpose of this major null hypothesis was to determine if a significant difference existed in the mean change scores on the entire general test (i.e., full scale) between the control and experimental group. This null hypothesis was rejected. As predicted, the experimental group achieved significantly higher change in scores than the control group, that is the computer group showed greater improvement.

Sub-null Hypothesis 1. The purpose of this sub-null hypothesis was to determine if a significant difference existed in the mean change scores on basic concepts and principles of modular fixturing of students who used the computer tutorial and those who experienced traditional teaching methods. This null hypothesis was rejected. As predicted, there were significant differences between group means with the experimental group improving more.

Sub-null Hypothesis 2. The purpose of this sub-null hypothesis was to determine if a significant difference existed in the mean of change scores on modular fixturing components of students who used the computer tutorial and those who experienced traditional teaching methods. This null hypothesis was rejected. As predicted, there were significant differences between group means, with the greater improvement in the experimental group.

Sub-null Hypothesis 3. The purpose of this sub-null hypothesis was to determine if a significant difference existed in the mean change scores on modular fixturing implementation of students who used computer tutorial and those who experienced traditional teaching methods. Here, also, rejection of the null hypothesis resulted. As predicted, the change scores also showed that there were significant differences between group means, again favoring the experimental group.

Incidental Finding

An important aspect of this experimental design is the measure of change from pretest to posttest scores. However, it was possible that some students in the control group may have had previous experiences with modular fixturing design before the instruction. For example, in the implementation section, control group participants started the experiment with a pretest score mean of 4.73 (out of 7). On the other hand, the maximum possible score of posttest would yield a mean of 5.07 (see Table 11). Therefore, many of the control participants could have improved their scores very little in any case. As a result, this would reduce the pretest to posttest possible improvement. In other words, the gain scores would be subject to a ceiling effect (personal communication with Dr. Andrew R. Gilpin, March 2001). Borg, W. R. and Gall, M. D. (1989) defined the concept of ceiling effect, as a situation where the range of difficulty of the test items is limited. Therefore, the test does not adequately measure the entire range of achievement possible on the dimension being measured. For example, if a student answers 20 items correctly on 25-item pretest, the student may only improve his or her score by 5 points on the posttest. In contrast, a student with a score of 12 on the pretest can make a potential gain of 13 points. Thus, the ceiling effect would place artificial restriction on the distribution of gain scores across level of initial ability. In another word, some students in the control group could earn only a minimum gain score when they took the posttest.

Table 12

Mean of the Pretest and Posttest Score Based on Four Areas of Knowledge (control group)

Area	Full Score	M (Pretest)	M (Posttest)
Basic Concepts	6	3.87	4.47
Components	12	7.67	9.20
Implementation	7	4.73	5.07
Full Scale	25	16.27	18.73

Miscellaneous Limitations

1. The pretest means of the control group for modular fixturing implementation on the pretest was slightly higher than the experimental group, indicating a high degree of background knowledge prerequisite to the material to be learned during this experiment.

2. The average time spent for the computer tutorial in the experimental group was 1 hour and 30 minutes, which was a much shorter lapse of time as compared to the control group (3 hours).

3. Students in the experimental group had not learned how to use the ToolTRAIN software before this research. Therefore, the researcher needed to spend about 20 minutes to explain the basic procedures on how to handle the computer tutorial.

Conclusions

This study was designed to improve instruction of modular fixturing design concepts. The computer tutorial program named ToolTRIAN was developed to provide a more efficient method for teaching modular fixturing concepts. This research found that there were significant differences between the computer tutorial program and lecture method. The experimental group who experienced ToolTRAIN achieved significantly higher improvement change in scores on the knowledge test as a whole, and in its subscales, than the control group. Also, the learning time spent using ToolTRIAN was less than the control group. Based on these results it could be concluded that this study lends support to the position that interactive multimedia tutorial program can be used as an effective teaching method for modular fixturing design concepts when taught to undergraduate industrial technology students. The study was limited by: (a) lack of type control of detailed content presented to the control group; (b) the small size of sample (15 subjects were in the control group and 15 subjects were in the experimental group); (c) the short duration of the treatment (one class session), and (d) the necessity to administer the control group and experimental group treatment one year apart.

Recommendations

Based on the findings and conclusions of the study, the following recommendations are made by the researcher (author):

1. This study should be replicated but with tighter control of control group module content.
2. Future research should expand the sample size used in the investigation.

3. ToolTRAIN can be used for more complex concepts of modular fixturing system and applications.

4. If this study is replicated, the experimental time needs to be extended. The learners should have sufficient time not only to learn the computer tutorial lessons, but also to learn to fully utilize ToolTRAIN.

5. A usability test with regard to the study of human computer interaction (HCI) should also be conducted for evaluating the ToolTRAIN program.

6. Students' learning attitudes and styles should be used as independent variables to determine other possible factors affecting success in using the computer tutorial.

7. More examples with animation capabilities and exercises should be provided in ToolTRAIN.

8. ToolTRAIN should be modified to include a concept of virtual reality that would permit the student to visualize a wider variety of modular fixturing applications.

9. ToolTRAIN should be fully implemented with a concept of an intelligent tutoring system (ITS).

10. Other authoring systems should be explored for development of an instructional program that might optimize enhances the exploratory aspects of learning.

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APPENDIX A

DEMOGRAPHIC SURVEY AND COMPUTER EXPERIENCES

Student Demographic Information Questionnaire

1. Name:
2. ID number:
3. Sex:
4. Year in school :

5. I would rate my knowledge of and experience with computer as...

    (a) Highly knowledgeable and experienced
    (b) Fairly knowledgeable and experienced
    (c) Somewhat knowledgeable and experienced
    (d) Little knowledgeable and experienced
    (e) No knowledge and experience

6. I would rate my level of experience with using computer tutorial as...

    (a) Highly experienced
    (b) Fairly experienced
    (c) Somewhat experienced
    (d) Little experienced
    (e) No experience

APPENDIX B

GENERAL CONTENT OUTLINE (CONTROL GROUP)

General Content Outline (Control Group)

I. Modular Fixturing

  A. Definition

  B. History

  C. Hierarchy

  D. Advantage

  E. Disadvantage

II. Components

  A. Plate and Blocks

  B. Grid Holes VS T-Slots

  C. Mounting Tools

  D. Locators

  E. Clamps

III. Implementation

  A. Fixturing Fundamentals

  B. Project/Case studies

APPENDIX C

DETAIL CONTENT OUTLINE (EXPERIMENTAL GROUP)

Detail Content Outline - Experimental Group

I. Modular Fixturing

A. Definition

1. Mr. Edward G. Hoffman
2. Dr. Teresa J. K. Hall (Video Clip)

B. History

Mr. John Walton developed and used the concept of several basic components in Glasgow, Scotland.

C. Hierarchy

1. Permanent Fixturing (special purpose)
2. Modular Fixturing
3. General Purpose

D. Advantage

1. One-Time jobs
2. Infrequent Production Runs
3. Prototype Parts
4. Replacement Parts that Are Made to Order

E. Disadvantage

1. Jobs That Will Repeat Times
2. Where Fixture Compactness Is Important

II. Components

A. Plate and Blocks

1. Regular Tooling Plates
2. Round Tooling Plates
3. Machining Center Pallets
4. Angle Plates
5. Riser Plates

Detail Content Outline - Experimental Group (Continue)

B. Grid Holes VS T-Slots

Two-primary forms of modular systems available today

C. Mounting Tools

1. Locating Screws
2. Riser Blocks
3. Riser Cylinders
4. Adaptors

D. Locators

1. Support Cylinders
2. Screw Rest Pads
3. Round and Diamond Locating Pins
4. Edge Supports
5. Extension Supports
6. Screw Jacks
7. Adjustable Stops
8. V Block
9. Spring Stop Buttons

F. Clamps

1. High-Rise Clamps
2. *Clamp-Strap Assemblies*

III. Implementation

A. Fixturing Fundamentals

1. 3-2-1 Concept
2. Dr. Ali E. Kashef (Video Clip)

B. Project 1
C. Project 2
D. Project 3
E. Project 4

APPENDIX D

EVALUATION INSTRUMENT (PRETEST)

MODULAR FIXTURING CONCEPTS
PRE-TEST

DIRECTIONS: Circle the letter of your choice for each item number below, which best completes the statement or answers the question.

Basic Information: Semester _________; Year _________.

Name:___________________________ Major:_________________________

1. In any fixturing tasks there are four essential elements:
   (a) Locating, supporting, clamping and referencing
   (b) Locating, locking, pushing and referencing
   (c) Referencing, locating, balancing and pushing
   (d) Rotating, supporting, clamping and revolving

2. The most common way to locate a workpiece from its external profile is
   (a) 4-3-2
   (b) 4-3-4
   (c) 3-2-1
   (d) 1-3-2

3. The first plane, which usually has the largest surface area, establishes the primary locating plane and is located by
   (a) 4 points
   (b) 3 points
   (c) 2 points
   (d) 1 point

4. Which of the following statement(s) is NOT the purpose of a modular fixture?
   (a) Reduce the cost of designing and building workholders
   (b) Decrease capabilities by fixturing more than one part
   (c) Design for automobile parts
   (d) Reduce the overhead costs by eliminating storage and maintenance expense

5. Which of the following statements is TRUE for a modular fixture?
   (a) Suitable only for aircraft components
   (b) Tool cannot be disassembled
   (c) Less time to build
   (d) Takes longer time to find a component than using dedicated workholders

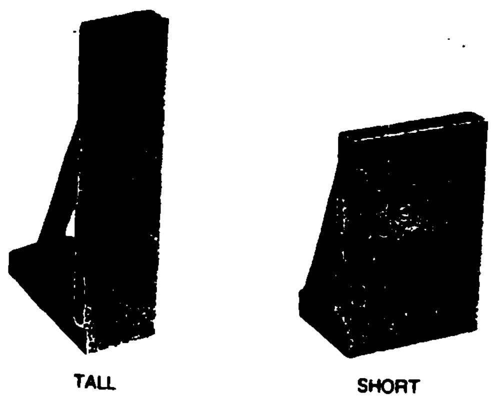
6. What is NOT a good application for modular fixturing?
   (a) Prototype parts
   (b) While permanent fixtures are built or repaired
   (c) In frequent production runs
   (d) Job that will repeat many times

7. What is the purpose of sub-plate modular fixturing systems?
   (a) Use as an angle-plate to support the friction saws
   (b) Use as a baseplate to slide under the working table of a machining center
   (c) Use as a baseplate to attach the locators and clamps need to fixture a part
   (d) Use as a coverplate to protect a part from chips and coolant

8. Sub-plate systems are available in two basic forms: Holes and _____slots?
   (a) T
   (b) V
   (c) U
   (d) C

9. According to question 8, what two-hole arrangements are used with hole forms (dowel pin systems)?
   (a) Alternating tapped holes separated with dowel pin holes AND combining both the locating and mounting functions into the same hole by mounting a locating bushing on top of a tapped hole.
   (b) Dowel pin holes separated with fixture nuts AND combining both the locating and mounting functions into the same hole by mounting a locating bushing on top of a tapped hole.
   (c) Alternating tapped holes separated with self aligning pads AND combining both the locating and mounting functions into the same hole by inserting a locating bushing on middle of a tapped hole.
   (d) Dowel pin holes separated with seating pins AND alternating tapped holes separated with dowel pin holes

10. Identify these tooling components.

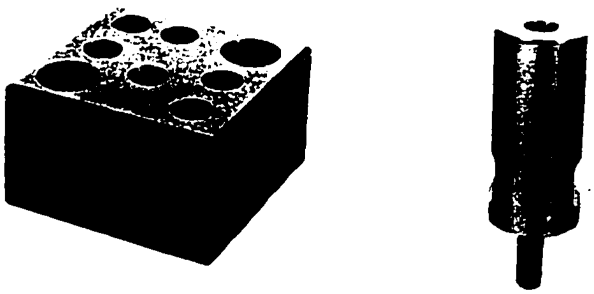


   (a) Tool-side tooling blocks
   (b) Platform tooling plates
   (c) Angle plates
   (d) Square pallet tooling plates

11. What makes the T-slot form differ from grid pattern (holes) in term of strength?
   (a) T-slot is stronger than grid pattern in all area especially two T-slot cross
   (b) Excessive forces cause problems when a component is located where two T-slot cross
   (c) Grid pattern forms are made from different materials
   (d) None of the above

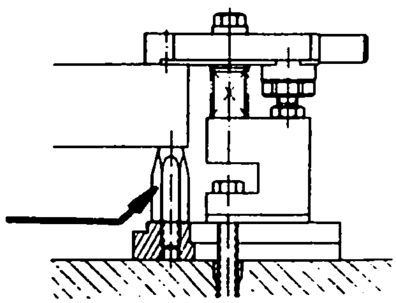
12. Which components can be used for elevating the mounting point of a clamp or locator?
   (a) Adaptors
   (b) Locating screws
   (c) Riser blocks and riser cylinders
   (d) Rubber sheet with locator knobs

13. Identify the components shown below.



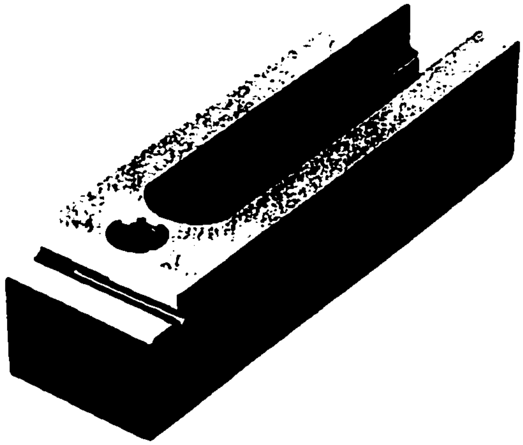
   (a) Adaptors
   (b) Measuring block and pin
   (c) Angle plates
   (d) Riser block and cylinder

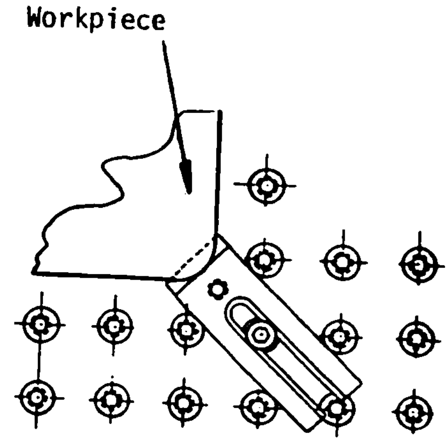
14. The following component is a



   (a) Screw rest pad
   (b) Spring stop button
   (c) Round locating pin
   (d) Diamond locating pin

15. What is the purpose of this device?

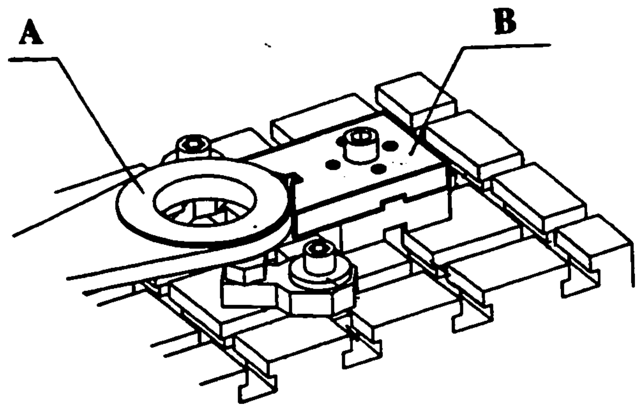




(a) Protect 4 corners of a workpiece
(b) Extend support
(c) Rotate a workpiece
(d) Align and located the baseplate

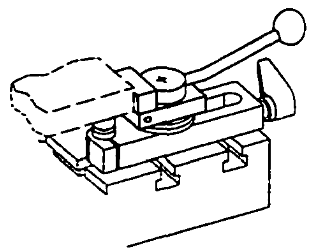
16. Which statement is TRUE for screw jacks?
(a) Heavy duty supporting elements that provide adjustable height
(b) Heavy duty rotating elements that provide adjustable height
(c) Heavy duty pulling elements that provide adjustable height
(d) Heavy duty pushing elements that provide adjustable height

17. What terms describe items "A" and "B" respectively?
(a) Positioning clamping cylinder and a workpiece
(b) Positioning clamping cylinder and a spacer
(c) A workpiece and a pin
(d) A workpiece and v-block



18. Which of the following statements describe the purpose of a clamping device?
    (a) To measure the distance from the machining area on the fixture
    (b) To support all loads from the primary locating plane
    (c) To hold the locators and supports
    (d) To hold the part against the locators and supports

19. What is the function of this device?

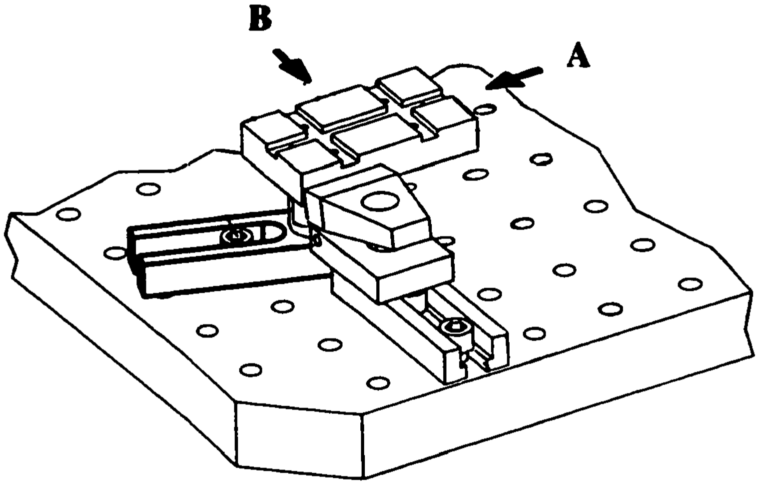


    (a) Quick-acting clamping element simultaneously presses the workpiece forward
    (b) Quick-acting clamping element simultaneously presses the workpiece backward
    (c) Quick-acting rotating element simultaneously pulls the workpiece backward
    (d) Quick-acting rotating element simultaneously presses the workpiece forward

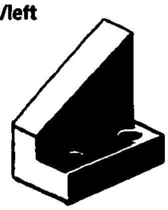
20. Which of the following statement(s) is NOT true?
    (a) The design should permit as many surfaces of the part to be machined
    (b) The entire workpiece must be located within the area of support of the fixture
    (c) Locator must be designed to resist all tool forces
    (d) Clamps should be located on datum plane Y and Z only

21. Modular fixtures (workholding) may be constructed in many different ways. The most common methods are:
    (a) Build the tool around a drawing (blueprint) OR build the tool around a mock-up (model of the part) OR build the tool to specific cost without any part.
    (b) Build the tool under a subplate OR build the tool around an angle-plate OR build the tool to specific dimensions without any part.
    (c) Build the tool around an actual part OR build the tool around a mock-up (model of the part) OR build the tool to specific dimensions without any part.
    (d) Build the tool around an actual part without any subplates OR build the tool around a mock-up (model of the part) without any subplates OR build the tool without any part.

22. According to the picture below, select the most appropriate component for position "A"

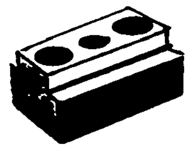


Block element 120° right/left



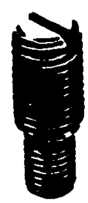
(a)

Positioning clamping bar, twin-faced



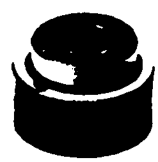
(b)

Thread bolt



(c)

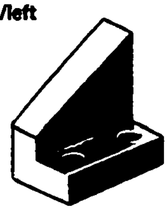
Positioning clamping cylinder



(d)

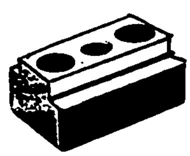
23. According to the picture for question 22, select the most appropriate component for position "B"

Block element 120° right/left



(a)

Positioning clamping bar, twin-faced

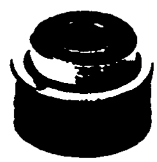


(b)

Thread bolt

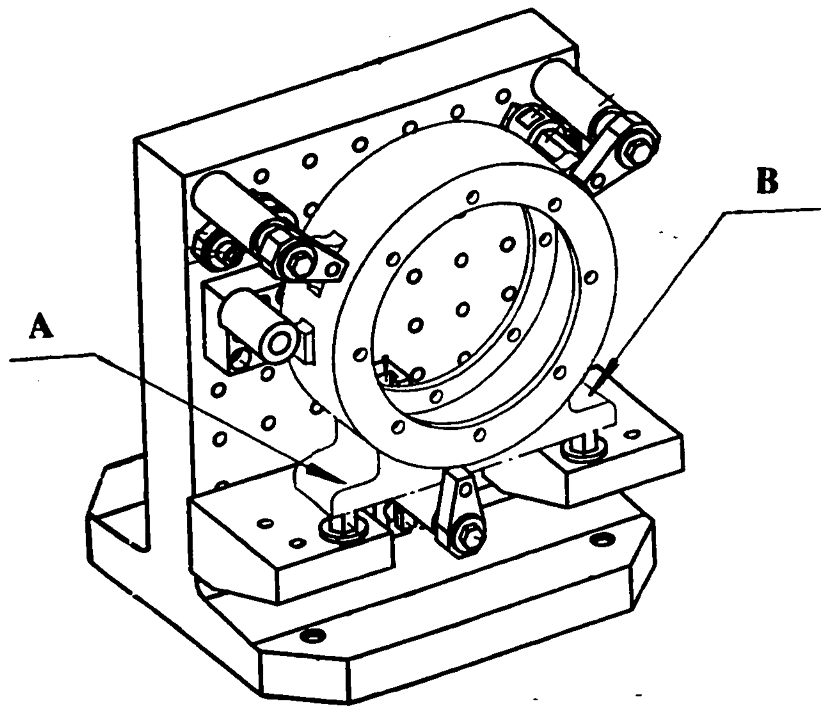
(c)

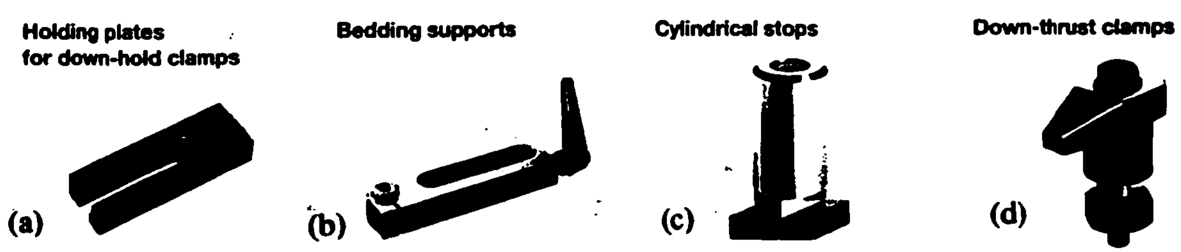
Positioning clamping cylinder



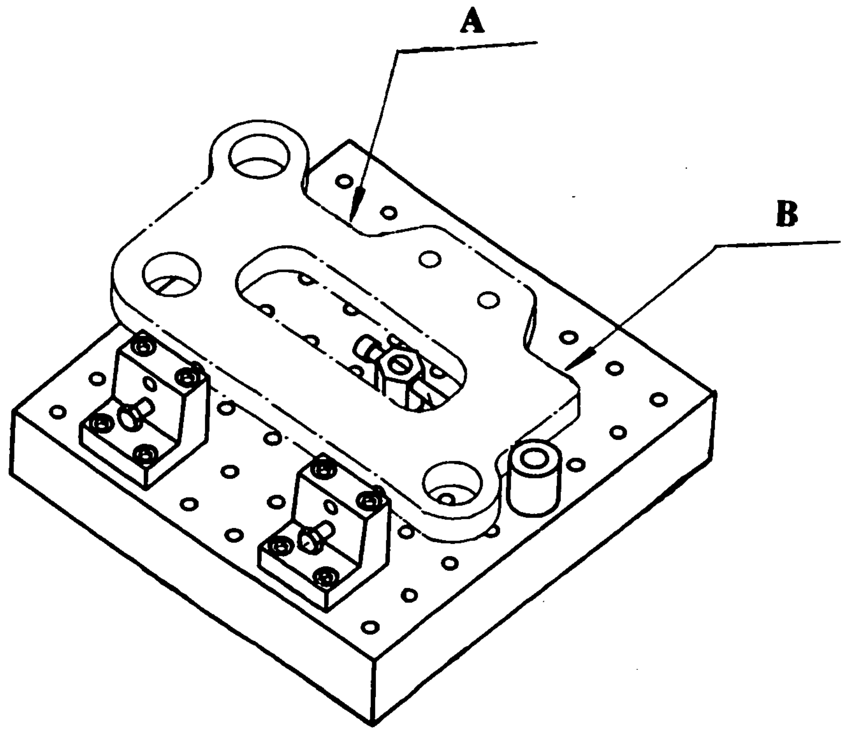
(d)

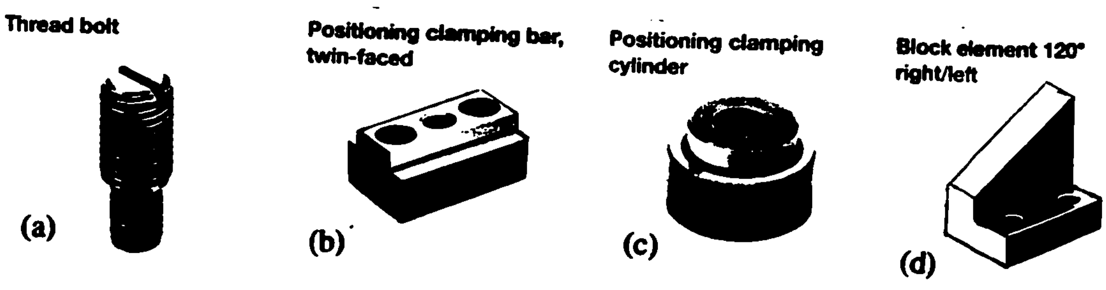
24. According to the picture below, select the most appropriate component for positions "A" and "B"





25. According to the picture below, select the most appropriate component for positions "A" and "B"





APPENDIX E

EVALUATION INSTRUMENT (POSTTEST)

MODULAR FIXTURING CONCEPTS
POST-TEST

DIRECTIONS: Circle the letter of your choice for each item number below, which best completes the statement or answers the question.

Basic Information: Semester _________; Year _________.

Name:___________________________ Major:_________________________

1. What is NOT a good application for modular fixturing?
   (a) Prototype parts
   (b) While permanent fixtures are built or repaired
   (c) In frequent production runs
   (d) that will repeat many times

2. Which of the following statements is TRUE for a modular fixture?
   (a) Suitable only for aircraft components
   (b) Tool cannot be disassembled
   (c) Less time to build
   (d) Takes longer time to find a component than using dedicated workholders

3. Which of the following statement(s) is NOT the purpose of a modular fixture?
   (a) Reduce the cost of designing and building workholders
   (b) Decrease capabilities by fixturing more than one part
   (c) Design for automobile parts
   (d) Reduce the overhead costs by eliminating storage and maintenance expense

4. In any fixturing tasks there are four essential elements:
   (a) Locating, supporting, clamping and referencing
   (b) Locating, locking, pushing and referencing
   (c) Referencing, locating, balancing and pushing
   (d) Rotating, supporting, clamping and revolving

5. The most common way to locate a workpiece from its external profile is
   (a) 4-3-2
   (b) 4-3-4
   (c) 3-2-1
   (d) 1-3-2

6. The first plane, which usually has the largest surface area, establishes the primary locating plane and is located by:
   (a) 4 points
   (b) 3 points
   (c) 2 points
   (d) 1 point

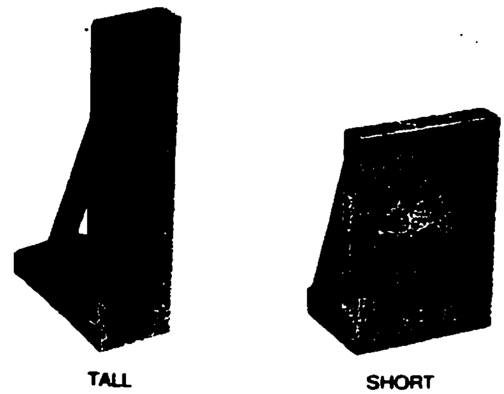
7. What is the purpose of sub-plate modular fixturing systems?
   (a) Use as an angle-plate to support the friction saws
   (b) Use as a baseplate to slide under the working table of a machining center
   (c) Use as a baseplate to attach the locators and clamps need to fixture a part
   (d) Use as a coverplate to protect a part from chips and coolant

8. Sub-plate systems are available in two basic forms: Holes and _____slots?
   (a) T
   (b) V
   (c) U
   (d) C

9. What makes the T-slot form differ from grid pattern (holes) in term of strength?
   (a) T-slot is stronger than grid pattern in all area especially two T-slot cross
   (b) Excessive forces cause problems when a component is located where two T-slot cross
   (c) Grid pattern forms are made from different materials
   (d) None of the above

10. According to question 8, what two-hole arrangements are used with hole forms (dowel pin systems)?
   (a) Alternating tapped holes separated with dowel pin holes AND combining both the locating and mounting functions into the same hole by mounting a locating bushing on top of a tapped hole.
   (b) Dowel pin holes separated with fixture nuts AND combining both the locating and mounting functions into the same hole by mounting a locating bushing on top of a tapped hole.
   (c) Alternating tapped holes separated with self aligning pads AND combining both the locating and mounting functions into the same hole by inserting a locating bushing in middle of a tapped hole.
   (d) Dowel pin holes separated with seating pins AND alternating tapped holes separated with dowel pin holes

11. Identify these tooling components.

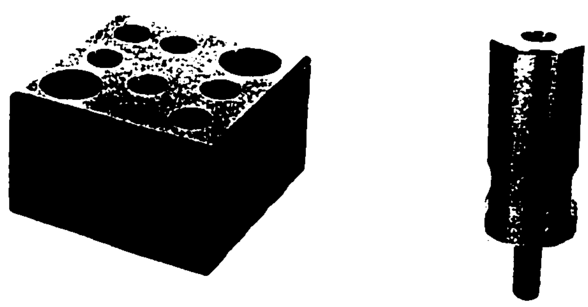


(a) Tool-side tooling blocks
(b) Platform tooling plates
(c) Angle plates
(d) Square pallet tooling plates

12. Which components can be used for elevating the mounting point of a clamp or locator?
(a) Adaptors
(b) Locating screws
(c) Riser blocks and riser cylinders
(d) Rubber sheet with locator knobs

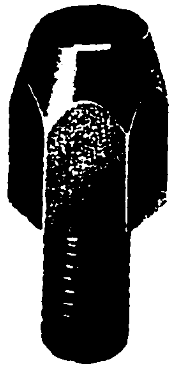
13. Which statement is TRUE for screw jacks?
(a) Heavy duty supporting elements that provide adjustable height
(b) Heavy duty rotating elements that provide adjustable height
(c) Heavy duty pulling elements that provide adjustable height
(d) Heavy duty pushing elements that provide adjustable height

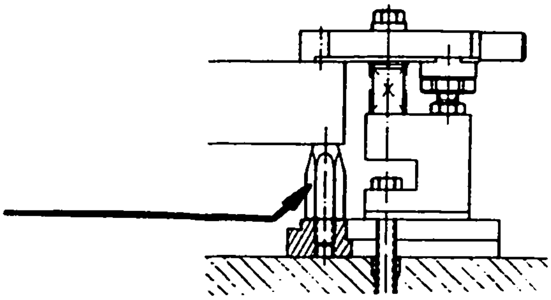
14. Identify the components shown below.



(a) Adaptors
(b) Measuring block and pin
(c) Angle plates
(d) Riser block and cylinder

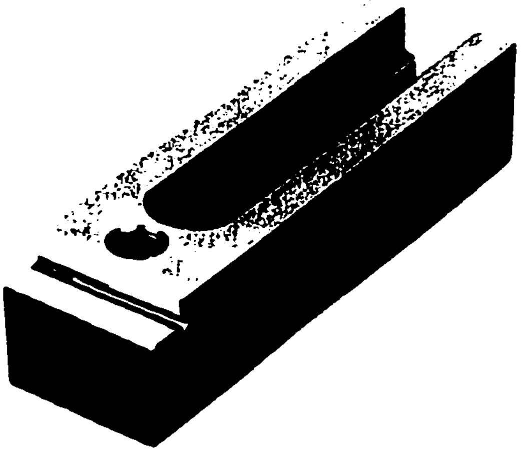
15. The following component is a

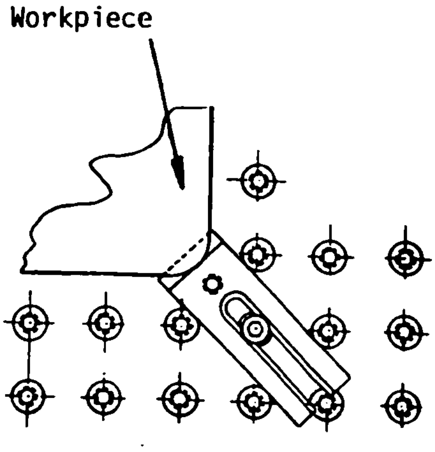




(a) Screw rest pad
(b) Spring stop button
(c) Round locating pin
(d) Diamond locating pin

16. What is the purpose of this device?

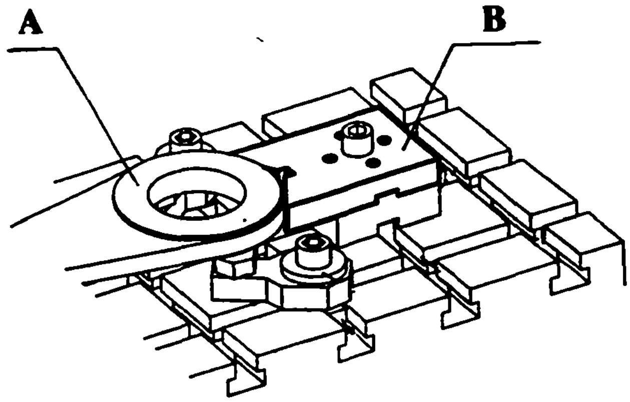




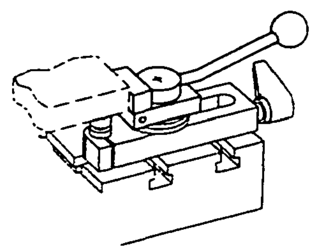
(a) Protect 4 corners of a workpiece
(b) Extend support
(c) Rotate a workpiece
(d) Align and located the baseplate

17. Which of the following statements describe the purpose of a clamping device?
(a) To measure the distance from the machining area on the fixture
(b) To support all loads from the primary locating plane
(c) To hold the locators and supports
(d) To hold the part against the locators and supports

18. What terms describe items "A" and "B" respectively?
    (a) Positioning clamping cylinder and a workpiece
    (b) Positioning clamping cylinder and a spacer
    (c) A workpiece and a pin
    (d) A workpiece and v-block



19. What is the function of this device?

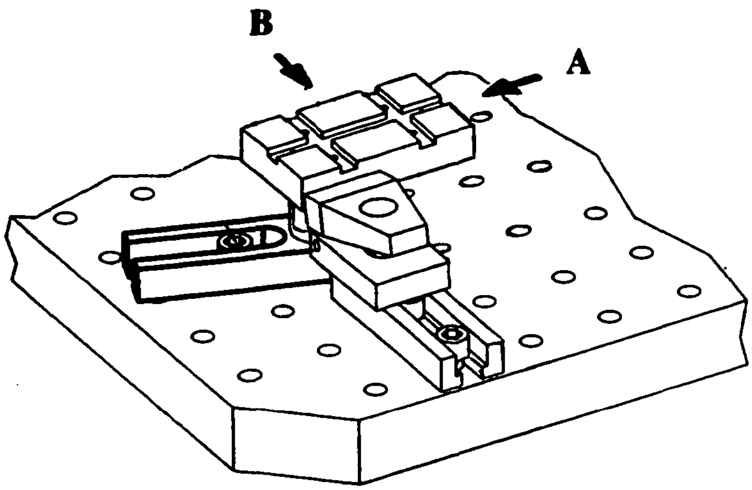


    (a) Quick-acting clamping element simultaneously presses the workpiece forward
    (b) Quick-acting clamping element simultaneously presses the workpiece backward
    (c) Quick-acting rotating element simultaneously pulls the workpiece backward
    (d) Quick-acting rotating element simultaneously presses the workpiece forward

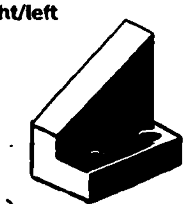
20. Which of the following statement(s) is NOT true?
    (a) The design should permit as many surfaces of the part to be machined
    (b) The entire workpiece must be located within the area of support of the fixture
    (c) Locator must be designed to resist all tool forces
    (d) Clamps should be located on datum plane Y and Z only

21. Modular fixtures (workholding) may be constructed in many different ways. The most common methods are:
    (a) Build the tool around a drawing (blueprint) OR build the tool around a mock-up (model of the part) OR build the tool to specific cost without any part.
    (b) Build the tool under a subplate OR build the tool around an angle-plate OR build the tool to specific dimensions without any part.
    (c) Build the tool around an actual part OR build the tool around a mock-up (model of the part) OR build the tool to specific dimensions without any part.
    (d) Build the tool around an actual part without any subplates OR build the tool around a mock-up (model of the part) without any subplates OR build the tool without any part.

22. According to the picture below, select the most appropriate component for position "A"

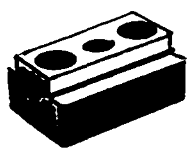


Block element 120° right/left



(a)

Positioning clamping bar, twin-faced



(b)

Thread bolt

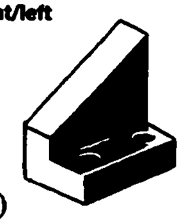
(c)

Positioning clamping cylinder

(d)

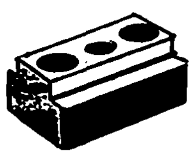
23. According to the picture for question 22, select the most appropriate component for position "B"

Block element 120° right/left



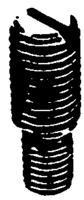
(a)

Positioning clamping bar, twin-faced



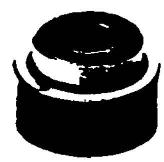
(b)

Thread bolt



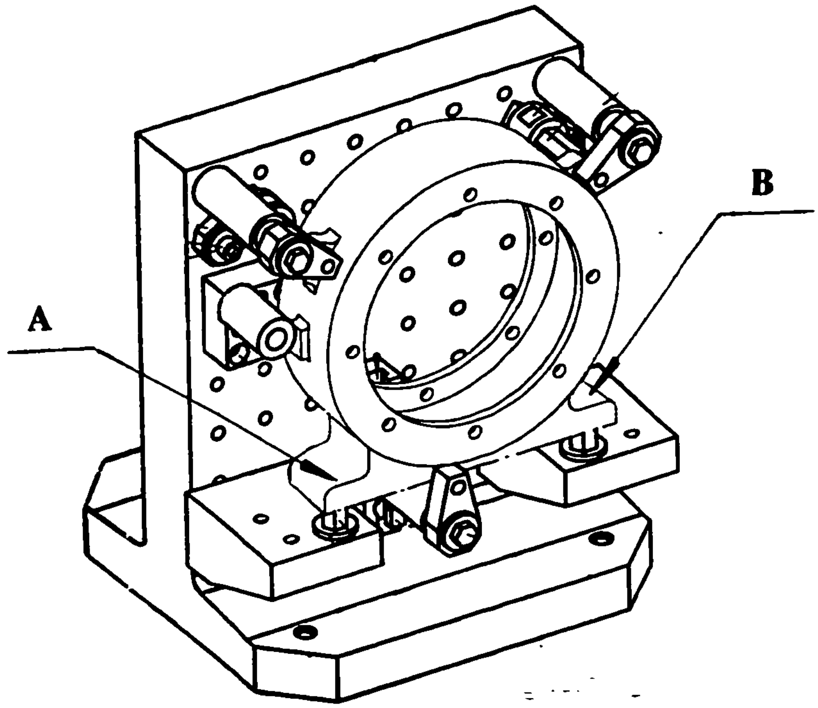
(c)

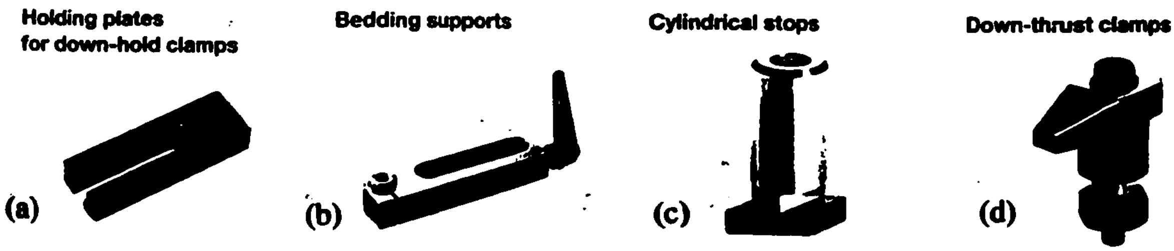
Positioning clamping cylinder



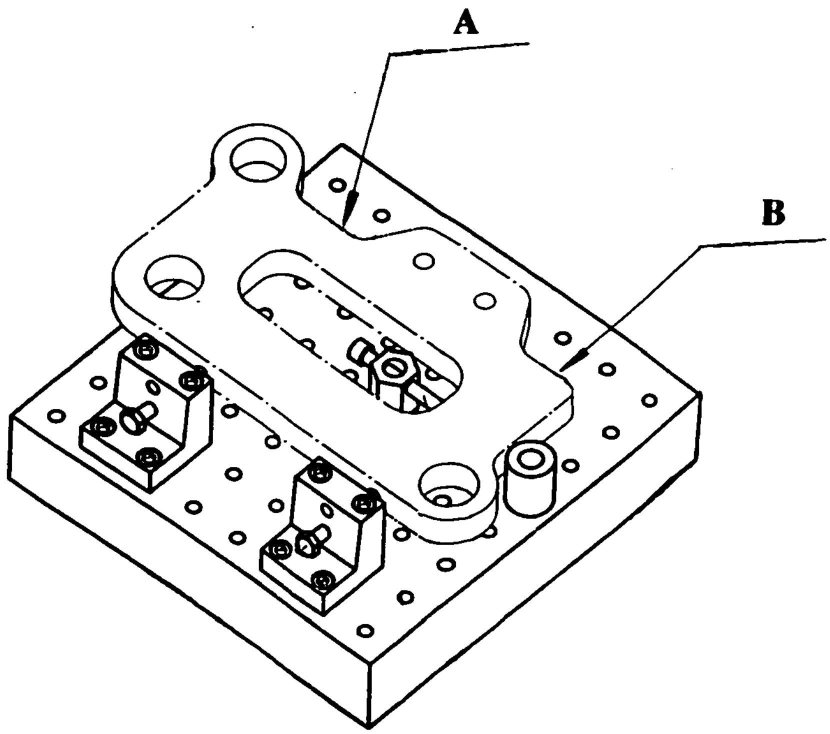
(d)

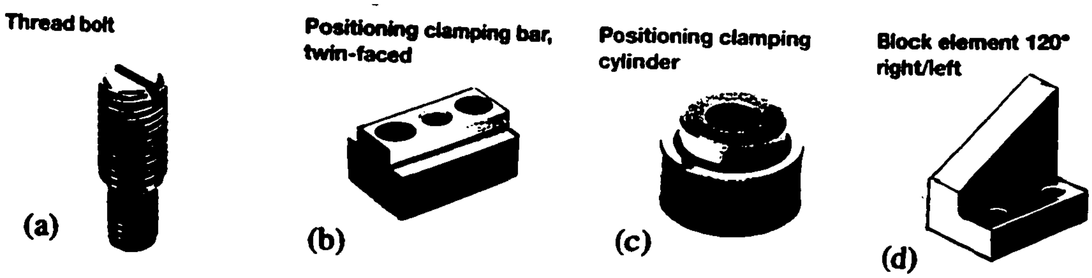
24. According to the picture below, select the most appropriate component for positions "A" and "B"





25. According to the picture below, select the most appropriate component for positions "A" and "B"





APPENDIX F

SOFTWARE AND TEST VALIDATION FORM

February 2, 2001

Veekit O'Charoen
305 G. St.
Cedar Falls, IA 50613

XXXXXXX
XXXXXXXXXX
XXXXXXXXXXXXXX

Dear Dr. XXXXXXX,

Thank you for agreeing to serve as a juror to determine the validity of a portion of my dissertation instrumentation. You have been selected for your expertise in the area of computer applications with the assumption that you are also knowledgeable about modular fixturing system or related filed such as basic concept of tooling, jig-fixture, and mechanical components.

You will be asked to go through computer tutorial software, which has been developed by the researcher on the topic of modular fixturing concept. The evaluation that you will be asked to complete consists of two parts. The first part is an evaluation of the program's content. The second part is an evaluation of the extent, to which the 25-item test measures the acquisition of knowledge based on the program's content.

A response form is included which can be completed and signed to document this evaluation for reporting my research. Please read through the documentation provided on the attached pages, which will briefly describe my dissertation topic. Once again, thank you in advance for your time and effort in assisting me with this research study.

Very sincerely,

Veekit O'Charoen
Candidate, Doctor of Industrial Technology
University of Northern Iowa

Overview of the Research Study

Research Title: Effects of Teaching Modular Fixturing Design Concepts via Interactive Computerized Multimedia Tutorial on the Cognitive Knowledge Gained for Undergraduate Industrial Technology Student.

Statement of Problem

The problem of this study was to evaluate students' cognitive knowledge in a concept of modular fixture, comparing teaching effectiveness of two different instructional technologies, either computer tutorial techniques or the traditional lecture method.

The purpose of the Research Project:

1. To develop and demonstrate the educational effectiveness of using an interactive computerized multimedia tutorial to teach a concept of modular fixture design at the undergraduate level, and
2. To investigate two different instructional methods (traditional lecture vs. computer tutorial) are equally effective in teaching the concept of modular fixture design.

Methodology

About 30 university level education students enrolled in Industrial Technology program at the University of Northern Iowa will be participating in the study. Each will be asked to engage in the computer tutorial, which has been developed by the researcher on the topic of modular fixturing concept. The data complied will be analyzed between the strength of learning style and knowledge gains as measured by the knowledge evaluation instrument.

Comments on the Development of This Software

A thorough understanding of modular fixturing system is quite important to the industrial technology students. This software (entitled ToolTRAIN) was designed to enhance the student's understanding of this subject. It may be used as a stand-alone instructional tool, or as a supplement to lecture and discussion.

The design and production of ToolTRAIN required a long period of time. In fact, many hundred of hours were spent developing this software tutorial. Further programs are under development and in the near future it is hoped that ToolTRAIN will be commercially available to industrial technology educators.

Veekit O'Charoen
305 G. St.
Cedar Falls, Iowa 50613
(319) 266-4918

Evaluation Form

The following rating scale and signature will serve as documentation for the review and evaluation of (1) the content of the computer software tutorial entitled ToolTRAIN Release 4 and (2) the accompanying knowledge evaluation instrument.

Disclaimer: This evaluation form will remain strictly confidential. Your name will be reported only as a member of the jury. Data will be reported without reference to individuals.

Content Evaluation Rating

Please rate the content of the computer software tutorial entitled ToolTRAIN Release 4 in term of accuracy and educational acceptability for college and university level students.

Circle one number (1-9):

Poor			Acceptable				Excellent	
1	2	3	4	5	6	7	8	9

Knowledge Evaluation Rating

Please rate the degree to which the knowledge evaluation instrument (test sample) developed for the computer software tutorial entitled ToolTRAIN Release 4 measures knowledge as indicated in the accompanying instructional objectives.

Circle one number (1-9):

Poor			Acceptable				Excellent	
1	2	3	4	5	6	7	8	9

______________________________ ______________

Signature of Juror Date

APPENDIX G

HUMAN SUBJECT CLEARANCE FORM AND LETTER

Informed Consent Statement

The Purpose of This Research Project

The purpose of this research is develop and demonstrate the educational effectiveness of using an interactive computerized multimedia tutorial to teach basic concepts of modular fixture design at the undergraduate level.

Your Rights

Participation in this research is voluntary. You are free to discontinue participation at any time. All of the information, which you will be providing, will be kept strictly confidential. None of this information can be traced back to you.

How You Will Be Asked to Participate (Tentative Schedule)

First, you will be asked to answer a 25 item test (pretest) in the ninth week of tool design class of spring of 2000 semester. In addition to completing the program, you will also asked to answer a 25 item test (posttest) in the eleventh week of tool design class of spring of 2000 semester.

Researcher: Mr. Veekit O'Charoen
Research Advisor: Dr. Ali E. Kashef

Department of Industrial Technology
University of Northern Iowa
Department Phone: (319) 273-2561

In you have any questions about the research or your rights in participating, please contact the office of the Human Subject Coordinator, University of Northern Iowa, (319) 273-2748

I am fully aware of the nature and extent of my participation in this project as stated above. I hereby agree to participate in this project. I acknowledge that I have received a copy of this consent statement.

____________________________ ____________
Your Signature Date

____
Please Print Your Name Above

____
Signature of Researcher

APPENDIX H

AN EVALUATION QUESTIONNAIRE OF TOOLTRIAN SOFTWARE

An Evaluation Questionnaire
ToolTRAIN Computer Tutorial Software
Spring 2001

1. Would you like to see more of this kind of software tutorial in a different class? For example, GD & T, Machine Design, Manufacturing Processes and Graphic Communication.
   a) Yes ( ) Why?________________________________
   b) No ( ) Why?________________________________

2. Was it difficult to know how to operate ToolTRAIN?
   Very Hard — Very Easy
   1 2 3 4 5 6 7 8 9

3. Was it difficult to remember the meaning of the commands to run the program?
   Very Hard — Very Easy
   1 2 3 4 5 6 7 8 9

4. Was the layout of the screen helpful to understand how to use the program?
   Not helpful — Very Helpful
   1 2 3 4 5 6 7 8 9

5. Did you feel comfortable with the color of the screen?
   Not Comfortable — Very Comfortable
   1 2 3 4 5 6 7 8 9

6. It is easy to go back and forth between screens of the program?
   Very Difficult — Very Easy
   1 2 3 4 5 6 7 8 9

7. Where the terminology used throughout the system clear and meaningful?
   Not Clear — Very Clear
   1 2 3 4 5 6 7 8 9

8. Are you satisfied with the way the information is arranged on the screen?
   Not Satisfied — Very Satisfied
   1 2 3 4 5 6 7 8 9

9. How would you rate ToolTRAIN software for the ease of use?
   Very Hard — Very Easy
   1 2 3 4 5 6 7 8 9

10. Were you satisfied with the time the experiment take using ToolTRAIN software?
   Not Satisfied — Very Satisfied
   1 2 3 4 5 6 7 8 9

APPENDIX I

LIST OF JURORS

List of Jurors

The following is an alphabetical list of the names and positions of the jury of experts used for the ToolTRAIN software and pretest-posttest.

Dr. Terry D. Goro, Coordinator Instructional Technology Services, Educational Technology Center, University of Northern Iowa.

Mr. Andrew Livin, Instructor, Department of Tool & Die Technology, North Iowa Area Community College.

Mr. Paul Stern, Mechanical Engineer and Information Technology Analyst (Manufacturing Specialist), Solid Modeling Support, Product Engineering Center (PEC), John Deere, Waterloo, Iowa.

Dr. Haig M. Vahradian, Program Assistant, Recycling and Reuse Technology Transfer Center, University of Northern Iowa.

Mr. Gary A. Volk, Professor, Department of Mechanical Technology, Illinois Central College.

Mr. David Wagner, Senior Designer, Product Engineering Center (PEC), John Deere Waterloo, Iowa.