Effectiveness of microcomputer aided television troubleshooting instruction using digital image database

Chien-Pen Chuang

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Chuang, Chien-Pen, Ph.D.

Iowa State University, 1990
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Effectiveness of microcomputer aided television troubleshooting instruction using digital image database

by

Chien-Pen Chuang

A Dissertation Submitted to the Graduate Faculty in Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Major: Industrial Education and Technology

Approved:

Signature was redacted for privacy.

In Charge of Major Work,

Signature was redacted for privacy.

For the Major Department

Signature was redacted for privacy.

For the Graduate College

Iowa State University
Ames, Iowa

1990
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CHAPTER I. INTRODUCTION

Background

Since their introduction in 1946, computers have changed the world. In 1964, the invention of the Integrated Circuit (IC) paved the way for the prevalence of this powerful machine. The advent of the microcomputer ensured itself an integral part in people's daily life - office, school, and home. Personal Computers (PC) have been used as an important tool in business for training, teaching and entertainment. A PC enables individuals to perform useful tasks such as numerical calculations, capturing and formatting text, and drawing for design or artistic purposes.

Clearly, most trends in computer technology tend to digitize every type of acquisitioned data, and the processing of digitized data is more accurate than the processing of analog data. Some computer manufacturers are attempting to unite television and the personal computer together - a new digital product which combines the controllability of personal computers with the realism of television images and sounds.

The technology of digital image processing was developed about thirty years ago and continues to expand rapidly. The increasing number of digital image sources includes remote sensing satellites and
systems, film scanners, video digitizers, digital sensors, biomedical systems, and military equipment systems. A variety of data types can be compactly stored, processed, and displayed in digital image format. Applications in diverse fields, including geology, astronomy, planetary science, meteorology, land use studies, forestry, cartography, agriculture, medicine, and military applications, effectively utilize digital image processing technology. However, there are very few applications of this high technology in school systems.

Although current Computer-Assisted Instruction (CAI) technology can be used to produce graphic displays, it can only create dots, boxes, circles, line drawings, or text on the screen at the desired locations with various attributes such as size, color, gap, logic, filling, among others. Basically, CAI is a bit-oriented data processing method, employing a low resolution, low memory storage system. The digital image processing can produce also pictures frame by frame. By contrast, it provides a high resolution, high memory storage, and a frame-oriented data processing method. With the low-cost system (compared to the mainframe system), multifunction microcomputer, the application of digital image processing in education becomes possible.

On the other hand, television, an analog medium for communication, is also an integral part of our daily life in the world today. There are thousands of television broadcasting stations and hundreds of millions of receivers in use. It brings us realistic pictures and
sound, capable of absorbing our attention and expressing our emotions. Clearly, television has changed the world we live in. Therefore, most of the developed and developing countries offer courses in television engineering or television techniques for vocational training at post-secondary schools or colleges.

For example, in Japan and Taiwan, most technical high schools and technical training centers offer "The Fundamentals of Television," "Television Theory and Troubleshooting," and "Digital Television." For post-secondary college, "Television Systems" and "Television Engineering" are offered in the department of electronic engineering. The same courses are offered for future technical high school teachers at the National Taiwan Normal University and the National Chang-Hua Normal University in Taiwan.

In the United States, some high schools, vocational schools, and junior colleges offer "Television Theory and Servicing," or "Television Troubleshooting," as courses. The main parts of the courses contain the principles of color television, the fourteen major circuits, and basic troubleshooting procedures.

In Taiwan, vocational high school students, who major in electronic techniques need to spend three hours a week studying television theory and another seven hours per week studying television troubleshooting. The total learning period is about 400 hours. At the Taiwan Normal University, students majoring in electronic technology need to study television engineering three hours a week and learn teaching television troubleshooting four hours a week for a semester.
For the last forty years, TV troubleshooting instruction has remained with a traditional delivery system. Teachers taught students to follow a one-by-one component approach in system diagnosis. This is a time consuming method for both students and teachers in this course. There should be some other method to improve this situation by using a microcomputer.

Statement of the Problem

The demand for improved teaching methods and media for television troubleshooting forced those teaching this course to search for a new strategy to solve this problem. One effective method may be achieved through the use of a microcomputer. By designing an interactive troubleshooting CAI courseware, it is proposed that the instructors will be able to teach television troubleshooting with less difficulty.

For many years, the instructors have used several traditional instruments to trace the defective components during laboratory activities. For example, a teacher may give a short lecture on interpreting the operation of a particular circuit, including input, output, and intermediate conditions. With the help of a block diagram or a schematic diagram, he/she can aid students to learn what he/she teaches. Then, he/she may use an oscilloscope to show the signal of a defective circuit. Step by step, students trace every component as instructed by the teacher. Students keep the results as a record for the particular learning activity.
If an oscilloscope is not sufficient for interpreting the phenomenon of the operation of a given circuit, other instruments such as sweep generator, marker, signal generator, television analyzer, pattern generator, and multimeter may be used to improve the teaching effectiveness. Thus, students should learn how to operate the related instruments in addition to becoming familiar with television circuits. The effectiveness of this teaching method is considered very inadequate and time consuming for students in Taiwan.

The multiplicity of television circuits is another factor that causes teaching difficulties in television troubleshooting. Some new television sets are equipped with fewer components than the traditional sets (most color television sets are equipped with more than 1000 components). However, the fewer the components, the easier the troubleshooting.

Several studies in Taiwan have indicated that some major problems still confront the teacher who attempts teaching television troubleshooting efficiently. These problems are as follows. There is difficulty in:

1. displaying the troubleshooting procedures clearly,
2. classifying the reasons for troubles correctly, and
3. diagnosing malfunction to the right part of the television quickly.

The application of Digital Video Interactive (DVI) technology may solve most of these problems. This research investigates the potential application of DVI technology for television (TV) troubleshooting instruction.
Purpose of the Study

The purposes of this research are:

1. to develop a microcomputer-based TV troubleshooting instructional system that would be useful to teachers in teaching TV troubleshooting,

2. to explore a model of integrating an image processing card with a computer in order to create an interactive teaching system for instructing TV troubleshooting, and

3. to evaluate the effectiveness of the DVI system when applied to teaching TV troubleshooting.

Objectives of the Study

The objectives of this study are:

1. to investigate the potential of a microcomputer-based teaching method and if it will save much learning time for students when learning television troubleshooting,

2. to develop necessary courseware for a microcomputer to be used in TV troubleshooting instruction,

3. to apply digital image processing technology in analyzing TV malfunctions and derive a quick diagnosis for the troubles, and

4. to evaluate the effectiveness of comparative results between traditional TV troubleshooting instruction and DVI instruction.

Assumptions of the Study

This study was aimed towards students who major in electronic techniques in industrial education departments in Taiwan. It was based upon the following assumptions. The subjects:
1. found that television troubleshooting procedures are an important concept and skill to acquire,

2. selected for this study have knowledge in microcomputer and microcomputer application skills,

3. completing this experiment did not have any prior learning in the DVI technology,

4. have already learned the fundamental theory of color television circuits,

5. have already learned the course of Audio-Video Electronics in a previous semester,

6. have been properly selected so that the results can be generalized to the general population of students who major in electronic technique in the Industrial Education Departments in Taiwan, and

7. any uncontrolled variables of the study were uniformly distributed over the entire sample.

**Delimitations of the Study**

The participating classes for his study were limited to those students who are majors in electronic techniques in the Industrial Education Department at the National Taiwan Normal University during the spring semester of the 1989-1990 school year in Taiwan. The subjects were training to become teachers in industrial vocational education in Taiwan.

The experimental units for this study were limited to three major circuits (vertical, horizontal, and color circuits) which were the most frequently found defective circuits in a common television set. These three were used to match the low memory size of a microcomputer that was used for teaching.
Procedures Used in This Study

The procedures used in this study were the following:

1. reviewed the related literature concerning the interactive courseware for instructing technical courses, DVI technology, and teaching methods of up-to-date television troubleshooting instruction,

2. developed necessary courseware for TV troubleshooting instruction with digital image processing technique,

3. designed pretest and posttest instruments,

4. identified the population and samples for the study,

5. administered the pretest,

6. implemented the experimental teaching,

7. administered the posttest and skill test,

8. administered the questionnaire,

9. collected research data,

10. coded and analyzed the data using the SAS package,

11. interpreted the findings,

12. wrote the summaries, conclusions, and recommendations.

Definition of Terms

1. Interactive Video System:

Any system in which the sequence and selection of a message are determined by the user's response to the material. A viewer's participation or involvement may take a number of different forms, such as answering questions, manipulating a control during
simulation, or simply choosing which segment of material to view from a menu. As a result, within the same program, a number of alternative or paths is available to different users and the routes followed by individuals may vary significantly (Floyd, 1982).

2. Digital Image Processing:
   A digital system for processing one or more images to produce a desired result. The processing can range from simple enhancement of an individual image for improved display of a detailed scene to more complex processing involving several component images or several hundred component images (Green, 1983).

3. Digital Video Interactive (DVI):
   DVI technology consists of four unique elements: a custom VLSI chip set which is the heart of the video system, a specification for a runtime software interface, some audio/video data file formats, and compression and decompression algorithms. Using these four elements, DVI can be implemented on any computer system that has sufficient power and storage capability (Luther, 1989).

   The CAVI system combines the CAI system with audio-visual devices, such as video discs, which provide the ability to merge video and audio with computer graphics. The best features of each medium can be used at the same time. Video instruction combined with a vocal explanation provides clear and detailed concepts that far exceed the
limited capabilities of the conventional computer system (Alton, 1986).

5. Expert System:

A combination of knowledge base and inference engine, together with supporting interface components that allows human beings to interact with the system. An expert system contains knowledge in the form of facts and rules, and an inference engine for specifying how the facts and rules are to be used to reach conclusions. The system is intended to emulate certain capabilities of a human expert, although the knowledge may be derived from a number of humans or from other information sources as well, such as books and manuals. An expert system is often referred to by the more general term "Knowledge-based System" (Edmunds, 1988).
CHAPTER II. LITERATURE REVIEW

The review of literature has been organized into five parts: principles of traditional television troubleshooting, strategies for teaching technical troubleshooting, effectiveness of computer-assisted instruction in school laboratory work, comparison of interactive video systems in education, and finally, the expert system for intelligent instruction.

Principles of Traditional TV Troubleshooting

Since 1929, television technology has emerged and developed through the vacuum tube period, transistor period, integrated circuit period, and to the Very Large Scale Integrated (VLSI) circuit period. Its frame quality has been improved from National Television Systems Committee (NTSC) 525 lines to High Definition Television (HDTV) 1125 lines. The integrated circuit not only processes the black\white signal, but also processes the color signal. In addition, stereo sound and the 3D picture have been developed by some big electronic companies.

The most significant feature for TV manufacture is the reduction in the number of components. With the miracle of VLSI technology, they have been reduced from nearly 1,500 to 50 (ITT digital TV). Yen (1988) stated that ITT Digit 2000 television used 6 VLSI and some other passive components (116 components) that do better than standard
television. Currently, TV technology is upgrading the digitalization and software control-oriented processes.

Cameron (1977) stated that the traditional TV troubleshooting methods advanced as the television manufacture technology and the instrument technology advanced. They could be called the "instrument-oriented" methods because the effectiveness of this skill depends largely on the instruments used for troubleshooting. Hence, the better the instrument used, the more efficient the troubleshooting.

The traditional TV troubleshooting principles includes the cause-and-effect reasoning principle, the signal tracing principle, and the signal injecting principle. They will be discussed next.

**Cause-and-effect reasoning principle**

This is probably the most useful principle for isolating the defective stage of the receiver. In this principle, it is assumed that the service technician has a knowledge of the circuit and its operation. In particular, the service technician must know the block diagram of the equipment being serviced. On the basis of this knowledge and the fault that exists in the receiver, the service technician can isolate the defect.

It is of the utmost importance that the television service technician be an expert in this technique, since it is the most rapid method of stage isolation available. Liff (1985) stated that this technique is mastered by first learning the block diagram of the TV receiver as well as how the receiver works and then by learning how to
interpret the symptoms that are seen on the screen of the picture tube or the sound heard.

**Signal tracing principle**

Signal tracing is the age old method of connecting a scope to a test point and comparing the waveshape to the waveform on the schematic. The idea is to move from one end of the circuit to the other until a waveform, or reading, that does not match those on the schematic is observed.

The basic method used when signal tracing a basic amplifier is shown in Figure 1. First, it is necessary to apply a signal to the receiver from an antenna or signal generator and then using an oscilloscope and its proper probes to follow the path of the signal as it passes through the amplifier. It should be kept in mind that not only is the amplitude of the observed signal important, but of equal importance is any change in waveshape from that indicated on the schematic diagram.

Signal tracing usually begins at the signal source where it is known that a signal is present and then works back toward the output end of the amplifier. The faulty stage is located by determining the two points corresponding to the last observed normal signal and the first observed abnormal signal. The fault must be in the circuit between these two points. Schulte (1986) stated that the success of this approach depends on the ability of the technician to analyze the waveform. However, it is not easy to recognize a small change in a waveform that could be a hint for a faster diagnosis.
Signal injecting principle

Signal injection, or signal substitution, is one of the more useful principles for isolating a defective stage in a television receiver. It is considered the opposite of signal tracing. To use this technique, a signal, whose frequency, waveshape, and amplitude are similar to the normal signal appearing at a given point in the receiver, is injected into that point from a signal generator. Figure 2 shows that replacing a lost signal with that generated by the signal generator should restore the receiver to its normal operation. If it
does restore the receiver, this may indicate that the stage being replaced is defective.

Another method for obtaining substitution signals is to use sections of a known good receiver to substitute for those sections of the defective receiver that are suspected of being faulty. In this case, the good section will restore the defective receiver to normal. A good source of injection signals is from commercially available substitution generators. They can supply RF, IF, audio, and chroma bar sweep outputs.

**Major procedures for traditional TV troubleshooting**

Liff (1985) concluded that the major procedures for traditional TV troubleshooting were as follows:

1. eliminate obvious defects,
2. isolate the defective stages, and
3. isolate and replace the defective component.

It can be seen from Figure 3 that the troubleshooting procedures match those with the principles previously stated. Liff also pointed out that the traditional methods of stage isolation do not always provide the fastest route to defective stage isolation. Cause-and-effect, signal tracing, and signal injection may not work for such troubles as intermittents, oscillation, or misalignment. These methods may also be ineffective for stage isolation in circuits that feed back over two or more stages.
Strategies for Teaching Technical Troubleshooting

Foshay (1987) investigated strategic approaches for technical problem-solving. He stated that the topic of teaching troubleshooting was examined as an example of teaching cognitive strategies for technical problem-solving. The traditional behavioral approach to teaching troubleshooting has essentially been algorithmic. Recent
1. Eliminate obvious defects

2. Isolate the defective stage

3. Isolate the defective component

4. Replace defective parts

FIGURE 3. Traditional TV Troubleshooting Procedures
cognitive research suggests an approach founded first on task analysis and characterized by:

1. analysis of the symbol system,
2. representation of the system under study,
3. identification of failure modes,
4. specific solution algorithms, and
5. derived heuristics which may be applied to guide linking of the detailed solution algorithms.

According to Forshay's analysis, there are two approaches to teaching troubleshooting. One is the "behaviorally based approach," and the other is "knowledge based approach." The behaviorally based approach to teaching troubleshooting is essentially algorithmic. For example, popular treatments such as Mager's (1982) recommendations. They include:

1. identifying the system's most common faults,
2. deriving one or more algorithms for troubleshooting each common fault using a split half strategy. A full analysis includes identification of conditions, actions, and feedback for each step,
3. sequencing instruction in each algorithm using sequencing rules,
4. teaching each algorithm separately, or teaching the steps in retrograde sequence, and
5. structuring practice of each step.

Thus it includes:

- Realistic stimuli (conditions)
- Realistic responses
• Immediate feedback on accuracy of the response, in detail, continue practice until the behavior is satisfactorily shaped

The limitations of the behavioral approach were criticized by K. D. Duncan (1985). He stated the criticisms as:

1. detailed procedure analysis of the sort is costly,
2. each system fault requires a separate algorithm or algorithm segment,
3. technicians resist using a fully algorithmic approach,
4. the algorithms are very situation specific and thus expensive to update,
5. retention of algorithm details is a constant problem, because most of the faults are rarely encountered and rarely practiced, and
6. transfer of troubleshooting skills to new systems or new faults is relatively low.

Recent cognitive research suggests some ways of overcoming some of these limitations. Most of them are knowledge-based approaches. Andre and Phye (1986) pointed out the distinctions between:

1. concepts which are stored as sets of multiple discrimination rules and as prototype examples,
2. production systems which include rules, principles, and skills,
3. declarative knowledge which supports the ability to classify or define, and
4. procedural knowledge which supports the ability to perform.

They reviewed some former researchers' concepts and defined the expert knowledge as the fundamental of knowledge-based approach. It included two types of knowledge:
1. Heuristic knowledge — generally applicable (but imprecise) production systems are used by experts to control problem representation and selection of solution strategy, and

2. Domain specific knowledge — experts have mastered large arrays of knowledge specific to a particular domain. This knowledge probably includes:
   1). the symbol system in use,
   2). the structure of the system,
   3). types of problems,
   4). problem solution algorithms, and
   5). strategies for applying heuristic knowledge to domain knowledge.

Schoenfeld (1988) thought that the heuristic strategies were nonalgorithmic procedures, "rules of thumb," or "tricks of the trade" for making one's way through complex tasks. Such procedures are not guaranteed to work or even be relevant to the task at hand; but if they do work, they often help one make significant progress.

Besides, there are several instructional strategies that deal with the knowledge-based approach for teaching technical troubleshooting. However, there is considerable controversy over whether this is really effective. For example, K. D. Duncan (1985) reported improvements in fault finding efficiency, but not accuracy, when various problem representation strategies were taught. Scandura (1986) concurred from both theoretical and empirical evidence that the use of separate instructional strategies is both less efficient and less effective.
While integrated teaching of concepts and production systems may be best for declarative knowledge, the opposite may be true of procedural knowledge such as the specific algorithms and general heuristics known by experts. Chaiklin (1984) argued that verbal representations of procedural rules assist novices as they master the rules, even though the verbal representations drop out when experts use the procedures. Furthermore, Chaiklin argued that even experts may return to verbal representation of the rules when confronted by a difficult problem.

However, Poshay (1987) developed an instructional strategy for IBM's CICS (Customer Information Control System) application programming system and demonstrated its effectiveness. The procedures he used were:

1. teaching the symbol system,
2. teaching the system through analysis of blocks,
3. teaching the failure modes by introducing the heuristic flowchart in interactive video,
4. teaching the heuristics by the presentation of each production system shown in the relevant flowchart, and
5. the learners were given a final exercise.

Feurzeig and Ritter (1987) developed an intelligent computer-assisted instruction system for teaching procedural skills. They acquired knowledge about a student's misconceptions and procedural bugs by making inferences based on the student's problem-solving actions. Thus, in work on electronic circuit troubleshooting problems, the
student's knowledge and difficulties were inferred from observations of the tests and measurements he/she made along the way. They proposed the alternate strategy of acquiring information directly from the student.

This strategy has been implemented as an instructional monitor within the QUEST system for training electrical system troubleshooting. Every time the student calls on the QUEST simulator to carry out a test or make a circuit measurement, the monitor asks the student the reason for his action. After the simulator performs the requested action, the system asks the student what he learned from the test or measurement. Student responses are made by selecting items in response windows and pointing at circuit components or subcircuits.

This approach can yield extensive information about the student's expectations, theories, and plans as a foundation for making inferences about his/her misconceptions and debugging ability. The strategy is therefore proposed as a valuable complement to pure inferencing methods.

Feurzeig (1988) concluded for the computer-centered teaching strategy that training can be aided, at least in part, through the use of appropriate computational environments and learning technology. The domain tools that are the principal instruments in this practicum can be augmented by learning tools and laboratory work expressly designed to support their use. A key point about the introduction and early use of the tools is that required knowledge is developed as necessary to
serve the effective use of the tools, not the other way around. The content of the discipline is not to be taught for its own sake, but to enable the student to advance the needs of a current project to be carried out with the tools.

The other approach for improving the efficiency of technical training is by way of "job aids." Job aids can reduce training time, while simultaneously increasing the quality of the performer's work. Harmon (1986) analyzed the necessary criteria when considering whether to use a job aid or a memorization strategy as illustrated in Table 1.

Harmon also categorized the types of job aids for training technology. He stated:

1. information aids provide the user with names, numbers, codes, etc.

2. procedure aids provide the user with a step-by-step procedure to follow,

3. algorithmic decision aids provide the user with a step-by-step procedure to use in decision-making,

4. heuristic decision aids provide the user with rules of thumb to use in making a decision.

According to Harmon's strategy, a technical teacher must do job analysis before teaching. He/she can use checklists, step-by-step procedures, cookbooks, worksheets, and other paper devices to do the analysis of teaching material. It helps students memorize some important knowledge and perform some tasks accurately.

But it is not easy to define which parts are available for memorization precisely, especially in the case of complicated
TABLE 1. Criteria to use when considering whether to use a job aid or a memorization strategy

<table>
<thead>
<tr>
<th>If</th>
<th>Then</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Response speed is more important than accuracy</td>
<td>Choose</td>
</tr>
<tr>
<td>* Task is frequently performed</td>
<td>Memorization</td>
</tr>
<tr>
<td>* Small errors will not have large consequences</td>
<td></td>
</tr>
<tr>
<td>* Reading instructions would interfere with performance</td>
<td></td>
</tr>
<tr>
<td>* Job prestige requires a memorized response</td>
<td></td>
</tr>
<tr>
<td>* Response speed is not as important as accuracy</td>
<td>Choose</td>
</tr>
<tr>
<td>* Tasks are infrequently performed</td>
<td>Job Aids</td>
</tr>
<tr>
<td>* Reading instructions will not interfere with performance</td>
<td></td>
</tr>
<tr>
<td>* Tasks involve many steps or a complex decision making process</td>
<td></td>
</tr>
</tbody>
</table>

Besides, if tasks are frequently performed, they may be memorized with practice and do not need to continue using job aids. Since the recent trend for training technology is to minimize memorization and maximize accurate responses, Harmon's statements cannot meet the diversity of technology instruction completely.
Effectiveness of Computer-Aided Instruction in School Laboratory Work

Many studies have been conducted in an attempt to determine the effectiveness of computers in education. Some investigators concluded more positive results for computer-aided instruction in classroom work than traditional instruction. Some concluded that it was only equal to the traditional instruction. However, researches for the effectiveness of computer-assisted instruction for school laboratory work showed more positive results than the traditional method.

Knerr and Nawrocki (1978) of the Army Research Institute for the Behavioral and Social Sciences made three research efforts that used computer-based simulations for maintenance training. They were Game-Based Learning, which investigated the use of computer-based games to train electronics diagnostic skills; Human Performance in Fault Diagnosis Tasks, which evaluated the use of context-free tasks to train individuals to maintain actual equipment; and the Adaptive Computerized Training System, which applied artificial intelligence techniques to electronic troubleshooting training. These efforts had the common goal of teaching generalizable diagnostic skills rather than equipment-specific procedures.

Preliminary findings suggested that each of the approaches could improve maintenance performance under certain conditions. Playing a logical game is an effective substitute for training in reading logic circuit diagrams, and practice in solving context-free diagnostic tasks enhances subsequent performance when diagnosing faults in equipment-
specific simulations. It was also found that feasibility of the Adaptive Computerized Training System had been demonstrated, though the system had not yet received rigorous experimental evaluation.

Trollip and Johnson (1982) investigated the computer application in an aviation training environment at the Aviation Research Laboratory at the University of Illinois at Urbana-Champaign. The experimenters reported that simulation has offered, for a long time, a partial solution to training needs in aviation. This is especially true in flight training where high aircraft acquisition and operating cost prohibit extensive use of real equipment. Simulation offers the potential of lowering training costs by minimizing the need for real equipment and by maximizing the learning effectiveness of real equipment when it is used.

Simulation increases the opportunities for individualized instruction, while providing an environment that is safe for trainees and nondestructive to real equipment. Trollip and John concluded that:

As flying and training costs escalate, an increasing use of computer-based training technology will be introduced. This will make the instructional process more efficient in terms of both time and cost. In addition, having such technology available will allow the institute to embark on a course of greater individualization of instruction with all its benefits (p. 226).

Taylor (1987) investigated the implementation and evaluation of a computer simulation game in a university course. In his study, the experimenter randomly assigned college students to a treatment group and a delayed treatment group. He compared lectures combined with the
computer simulation game to lectures alone by testing a broad range of measures (attitudinal, attendance, achievement, and information-seeking behavior). He concluded that students responded favorably to the computer simulation game. He also found that students who participated earlier in the semester using the computer simulation game responded more favorably to the computer simulation game than those who participated later.

Castro (1990) developed a software package for teaching "Digital Signal Processing" at the University of Surrey in England. It was found that student's understanding can be significantly enhanced by hands on experimentation and the practical aspect of such courses can now be achieved using appropriate microcomputer software. The package enables students to make their own measurements of many of the important signal characteristics, and hence, discover for themselves the influence of changes in the various sampling parameters. It has been a clear improvement for student's understanding both amplitude domain and time domain statistics in the laboratory experiment (pp. 19-27).

On the other hand, several studies concluded that there were no significant differences in student's achievement whether traditional instruction or computer-aided instruction was used.

Morrison and Witmer (1983), also of the U.S. Army Research Institute, conducted a comparative evaluation of computer-based and printed-based job performance aids. They developed a computer-based
job aid from a previously developed print-based aid and compared task performance of soldiers using the two kinds of aids. The main body of the print-based job aid consisted of step-by-step procedures for performing each M1 tank gunner's task. The print-based job aid was a ring-bound plastic covered booklet. Steps were numbered and listed in the sequence they were to be performed. Because of certain contingencies which can exist between task steps and the status of certain controls and indicators, an algorithmic format rather than a straight sequential listing was used. Therefore, certain points in the procedure, soldiers were asked questions concerning the phase of status operation of controls and indicators. Based on their answers, the soldiers were required to follow branching to an appropriately numbered step.

The computer-based job aid used an Apple II-plus microcomputer. The text and format of the job aid program were the same as the print-based aid. The most important difference, when comparing with the print-based job aid, was that the computer-based program automatically branched to appropriate steps when the soldiers responded to questions posed by the program.

The experimenters expected that the computer-based job-performance aid would produce desired results faster and more accurately than the print-based aid, because of the automation of task sequencing and branching. The results did not support these expectations. There were no differences in task completion time between the job aids. Since the
operations of M1 tank gunner's task are very simple and there are only few impedances existing between man and computer interface, it is clear that the experimenter can not get the expected results.

According to Schoenfeld's (1988) prediction that by 2020 information technology will have become such an integral part to everyday life and will transform how we do what we do. It will inevitably affect both what is taught and how it is taught. Computer-based tools will have become central and essential for work in all disciplines. Because of the continued advances in technology, relatively inexpensive computers will have the performance power, devices, communications, and software tools required to support applications employing extensive computation, real-time simulation and control, interactive displays, and artificial intelligence. Thus, many computer-based tools used by scholars, scientists, and artists will be accessible to schools and homes.

Comparison of Interactive Video Systems in Education

Interactive video systems have become a valued educational tool. Traditional forms of computer-based instruction, drill and practice, tutorial, and simulation, can be enhanced with interactive video. Instead of being restricted to the computer's often limited graphics and sound, the sound and clear visuals of the video disc can be made an integral part of instruction.
Malenke (1988) classified the interactive video technology into three steps by chronological order. They are video cassettes, video discs and digital video interactive.

**Video cassettes**

Video cassettes are products of the 1970s that were bulky, but have since been reduced in size. Video cassette recorders are extremely practical in the classroom for both instruction and remediation. The advantages of video tapes educational technology are:

1. video tapes can be multiple recorded and reproduced.
2. video tapes offer extended lesson play time, and
3. video tapes are less expensive.

Unfortunately, video tapes have the following major drawbacks for use as educational aids (Gerstein and Sasnett, 1987):

1. It is difficult and time-consuming to access any part of the material at will, necessitating long and inaccurate searches.
2. Image quality is doomed to deterioration due to contact between the physical media and its playback device, making it difficult to maintain archival quality over time.
3. The presentation is 'cast in stone' and cannot be altered.
4. The coordination of supplementary documents with the visual content is clumsy and expensive.
5. It is impossible to provide a table of contents due to the lack of built-in addressing mechanisms.
Video disc interactive

Video discs are a more recent development (late 1970s). They resemble phonograph records and are played on units that resemble audio turntables. There are four different formats; none of them compatible. Two of them use laser light to pick up signals and two use a physical stylus. The advantages of educational interactive video discs are:

1. video discs permit rapid access to any segments of a lesson,
2. video discs are read without physical contact. They are exceptionally durable,
3. video discs offer excellent display quality and slow motion display, and
4. video discs can be identified with a unique frame number, allowing precise and rapid "frame accurate" location of lesson segments.

The disadvantages of video discs are:

1. video discs are a read only memory or write once media. It does not permit multiple recording, and
2. They are more expensive than video tape system.

Digital video interactive

The DVI technology was first shown publicly at the Second Microsoft CD-ROM Conference in Seattle on March 1, 1987. It was first developed by RCA, sold to GE, and then extensively developed by the Intel Corporation. This technology consists of four unique elements:

1. a custom VLSI chip set, VDP (Video Display Processor), which is the heart of the video system,
2. a specification for a runtime software interface,
3. some audio/video data file formats, and
4. compression and decompression algorithms.
The bottom level is hardware that "talks" directly by drivers which are installed at boot-up and remain resident thereafter. (Note: A driver is a software module, which provides interface to a particular piece of hardware.) There is one driver for the video board, one for the audio board, and one for the utility board. These drivers are not accessible
to application programs, except through the driver interface modules
which rest above the drivers. The drivers themselves are terminate-
and-stay-resident programs which are loaded when the computer boots up
and then remain in the system RAM. The remaining runtime software is
contained in the system libraries, which become part of an application
program through linking.

Luther (1989) analyzed the advantages of DVI technology. His
conclusions were as follows:

1. DVI can be used on any type of computer.

2. It is a PC-based interactive all-digital audio/video system
that can play television-style video and sound as well as do
all things with graphics and sound that personal computers
now do.

3. It can merge text with a color picture on a single monitor.

4. The digital images can be edited, reformatted, and processed
with any digital image processing method.

5. All data can be loaded and processed at any time.

However, if one compares the Video Disc-I to DVI as shown in the
Table 2, the disadvantages of the DVI technology are:

1. it is too expensive at the present time, and

2. the standard of the interface has not yet been set up.

**The total interactive learning system**

The total interactive learning system can be organized as
illustrated in Figure 5. It consists of a VCR, laser disc and a
microcomputer with an image processing card to form one system. The
TABLE 2. Comparison between Compact Disc-I and DVI

<table>
<thead>
<tr>
<th>Features</th>
<th>Compact Disc-I</th>
<th>DVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Playtime</td>
<td>72 minutes, partial-screen motion video</td>
<td>72 minutes, full-screen motion video</td>
</tr>
<tr>
<td>Disc Speed</td>
<td>Plays at normal CD speed, 200-500 rpm</td>
<td>Plays at normal CD speed, 200-500 rpm</td>
</tr>
<tr>
<td>Picture Resolution</td>
<td>384x280 full screen for partial screen motion video</td>
<td>256x240 for full-screen motion video at 30 frames per second</td>
</tr>
<tr>
<td>Video Still-Frame</td>
<td>Up to 5,000 natural pictures per disc 384x280 resolution</td>
<td>Up to 7,000 stills at high resolutions 768x480</td>
</tr>
<tr>
<td>Encoding</td>
<td>Digital compression DYUV and run-length encoding</td>
<td>Digital compression on VAX computer at 30 seconds/frame</td>
</tr>
<tr>
<td>Hardware Configuration</td>
<td>Stand-alone player includes microprocessor operating system A/V processors</td>
<td>Set of three add-in boards, requires MS-DOS computer and standard CD-ROM drive</td>
</tr>
<tr>
<td>Accompanying Audio Track</td>
<td>Flexible ADPCM fidelity levels</td>
<td>Flexible ADPCM fidelity levels</td>
</tr>
<tr>
<td>Price</td>
<td>$1,000-1,500</td>
<td>$3,000-5,000</td>
</tr>
<tr>
<td>Originator</td>
<td>Phillips/Sony</td>
<td>RCA</td>
</tr>
</tbody>
</table>

function of this total system may be expanded to the extreme. But, there are some overlaps in the hardware configuration that will cause too much waste.
Luppa and Anderson (1987) analyzed the total interactive learning system and summarized their observations:

The total interactive learning system does far more than overlay computer text and graphics over the video image. It uses the computer to create high definition "video quality" images and then integrates those images into the video presentation. In this way the computer image almost becomes part of the video image and can be manipulated far faster than even the very best video image. This kind of integration is used in high-level simulations including arcade video games...(p.135).

However, interactive video training is an educational method that combines the best features of classroom and audiovisual instruction, while adding some features found in no other training medium. It has been proven to possess a high degree of applicability to critical performance communities such as the U.S. Navy (Cantor, 1989). Multi-media presentation formats have been documented to be very successful in motivating students, stimulating the learning processes, and enhancing the retention of the learning experience (Priestman, 1984).

Interactive video disc systems capitalize upon media traditionally used for instructional presentations: stills (slides, viewgraphs, photographs); motion (motion picture film); sound (audio cassettes); graphics (drawings, diagrams, etc.); and text (books). In addition, interactive video disc adds the power of the computer for computation, programmable procedures and branching logic to control and combine the media. Furthermore, digital video interactive technology expands the function of multi-media to create an extraordinary presentation. It can provide immediate feedback for the student, and exercise and
prescribe all the learning activities based on the student's performance.

**Expert System for Intelligent Instruction in Education**

As technology advances so does the complexity of most equipment. Consequently, it is becoming increasingly difficult for people to know all there is to know about repairing equipment and machinery. The knowledge and cognitive process skills that are needed for troubleshooting and repair are becoming increasingly valuable. The problem lies, however, in our lack of understanding the knowledge and skills that are required to perform the complex task of troubleshooting faulty equipment. It is apparent that if an expert system exists, it should be possible to get the answer from this system easily.

**Intelligent tutoring system**

The intelligent tutoring system involves computer programs that use Artificial Intelligence (AI) techniques to help a person learn. The design and development of such programs lie at the intersection of computer science, cognitive psychology, and educational research. Hence, it requires a mutual understanding of the three disciplines involved. This is a very difficult demand, given the problems of keeping up with even a single discipline today.

Kearsley (1987) depicted five major paradigms (as illustrated in Figure 6) that currently make up the Intelligent Computer Assistant
FIGURE 5. The Total Interactive Learning System
Instruction (ICAI), also called Intelligent Tutoring System (ITS).

They are:

1. Mixed-initiative dialogues:
   This is the original ICAI paradigm. In this type of ICAI, the program engages the student in a two-way conversation and attempts to teach the student via the socratic method of guided discovery. This paradigm best fits conceptual or procedural learning tasks.

2. Coaches:
   A coach observes the student's performance and provides advice that will help the student perform better. This type is best suited for problem-solving programs (e.g., simulations and games).

3. Diagnostic tutors:
   These programs are driven by a "bug catalog" that identifies the misconceptions that students may have in solving a problem. Diagnostic tutors are appropriate for almost any type of problem-solving situation.

4. Microworlds:
   This paradigm involves developing a computational tool that allows a student to explore a problem domain such as geometry, physics, or music. It is the closest paradigm to traditional computer-based instruction.

5. Articulate expert system:
   This paradigm can be used as job aids and provide practice in problem-solving and decision-making skills. It has many potential applications in the training domain.

To summarize, ICAI or ITS programs representing different paradigms often bear little surface resemblance to each other. However, the underlying research issues and AI techniques used in these programs are quite likely to be similar.

The procedures for developing an expert system for teaching procedural skills
FIGURE 6. Intelligent CAI paradigms

Johnson (1987) investigated knowledge and skill differences between expert and novice service technicians on technical troubleshooting tasks. He developed a hypothesis testing method to solve the troubleshooting problems. The model Johnson created is very useful for developing an expert system. Figure 7 shows the technical troubleshooting model. It includes the "hypothesis generation phase" and the "hypothesis evaluation phase." In addition to this, the procedures Johnson used for developing an expert system consist of the following steps:

1. Problem formulation
2. Problem space representation

3. Problem solution sequence

The study illuminated three areas that must be emphasized to improve technical instruction. First, for technical instruction to be effective, the content domain must be adequately and completely defined. Second, technical instruction must include content that is specifically related to the technical system under study. Trainees must be taught the function and operation of the technical system. Third, the instruction should provide trainees with realistic learning experiences. Trainees should be given systems that do not function properly and have them work through the troubleshooting process to identify system faults.

Methodology for building an intelligent tutoring system

An intelligent tutoring system is a computer program that uses AI techniques for representing knowledge and interacting with a student (Sleeman and Brown, 1982). This work derives from earlier efforts in computer-aided instruction, but differs in its attempt to use a principled or theoretical approach. First and foremost, this entails separating subject material from the teaching method, as opposed to combining them in ad-hoc programs. By stating teaching methods explicitly, one gains the advantages of economical representation and the discipline of having to lay out subject material in a systematic, structured way, independent of how it is to be presented to the student.
FIGURE 7. Technical troubleshooting model
Clancey (1987) and his colleagues spent five years developing a computer program "MYCIN" to teach medical diagnosis. The general problem has been developing an "intelligent tutoring system" by adapting the MYCIN expert system. The particular tutoring system was built upon the knowledge of the MYCIN expert system. MYCIN's rules have to be restructured in order to be applied to teaching; the new system was called NEOMYCIN. The methodology for building NEOMYCIN involved the use of the rules of MYCIN to provide good advice to the student. The rules were acquired by discussing with physicians for many hours, comparing the program's behavior to their judgment, modifying rules to improve the program, and testing the program on new problems.

The framework of structural, support, and strategic knowledge for organizing, justifying, and controlling the use of heuristic rules serves well in knowledge acquisition dialogues. Not only by asking each other related questions, but Clancy analyzed the results by meeting with experts. Then, knowledge was organized around each rule they discussed. The general methodology that Clancey and his colleagues followed was:

1. Formulate design guidelines
2. Model system on paper
3. Code/modify program
4. Experiment with program
5. Analyze program behavior to determine shortcomings
6. Theorize/reformulate model to eliminate shortcomings
The research problems that have been suggested by their work are listed as follows:

1. The structure of working memory
2. Identifying lines of reasoning
3. The effect of problem context
4. Clustering of hypotheses for manageability
5. Experimentally verifying diagnostic strategy
6. Explanatory theory of strategy
7. Modeling belief
8. Shifts of attention and noticing subproblems
9. Effect of level of abstraction on problem formulation
10. Observation strategies

Clancey concluded that the strength of cognitive science is surely the way theories are changed and suggested by the very process of building computational models. Too often experimental analysis seems to fall short by not being precise enough to be programmable. Or, the simplifications to make an experiment tenable eliminate the very points that we need to build a working system.

However, Woolf et al. (1986) stated that the more powerful tutoring systems contain a more sophisticated knowledge of the domain. Domain knowledge requires an investigation into an expert's understanding of the laws of the domain. The one characterized by at least four kinds of knowledge:

1. Declarative (data)
2. Procedural (rules and processes by which the data are used)
3. Heuristics (rules of thumb that guide the use of rules)

4. Simulation (rules needed to graphically implement the data and rules)

Technological advances, such as affordable AI-based work stations and expert systems tools, allow construction of powerful computers for education. These computers should be able to reason about the domain, the student, and the discourse, and to teach in a sensitive one-on-one dialogue with a student. Such a computer will customize its responses to the complexity of the domain, to the specific event, and to the idiosyncrasies of the student. To do this, the developer of a tutoring system must have knowledge of the domain, of the student, of the tutoring system, and of the discourse.

Summary

The principles of traditional TV troubleshooting

The principles of traditional TV troubleshooting, as Schulte (1986), Liff (1985), and Buscome (1984) stated, follow three steps: 1) eliminating obvious defects, 2) isolating the defective stage, and 3) isolating and replacing the defective component. The elimination of obvious defects requires that all senses be used to find the fault. Isolating the defective stage usually consists of three methods: 1) cause-and-effect reasoning, 2) signal tracing, and 3) signal injection.

If a service technician knows the circuit, then cause-and-effect reasoning is the most rapid method of stage isolation. If not, then
Other methods must be used. More instruments and signal generators must be used to determine the location of faults in a defective receiver.

Signal tracing usually begins at the front-end and works back toward the output end of the amplifier. Since TV receivers are designed with several built-in self-generating signal sources, it is not necessary to apply any other signal source to the receiver when a student traces these stages. But, this method still consumes much time in the work of tracing.

Signal injection is the opposite of signal tracing. It has been proven to be a super timesaver in troubleshooting TV circuits. Schulte (1986) discovered that signal injection can solve one of the toughest problems of today's service technician -- checking ICs. The technicians do not need to measure every voltage on the various pins with the use of the signal injection method. The only thing a student needs to do is inject a good signal into the input terminal of a circuit and then measure the output signal. Yen (1988) also supported this method and stated that it was efficient for troubleshooting digital television.

No matter how efficient the traditional methods became, there were still some unsolved problems. The intermittents and oscillation troubles still bother the service technicians. In addition, the work of TV troubleshooting is still time-consuming. This means that the teaching method really needs to be improved.
The strategies for teaching technical troubleshooting

Even though there have been few research studies about teaching technical troubleshooting, some researchers have contributed to this field. Schoenfeld (1988), Foshay (1987), Andre and Phye (1986), and K. D. Duncan (1985) examined teaching troubleshooting as the work of technical problem-solving. They found the traditional behavioral approach to teaching troubleshooting has essentially been algorithmic. Their cognitive research suggests an approach founded first on task analysis and characterized by the ideas of systematicism: symbol system, sequential instruction, structure practice, and immediate feedback on accuracy of the response.

The behavioral approach for technical troubleshooting instruction has been shown repeatedly to be effective. However, this approach has not been without critics. K. D. Duncan (1985) pointed out that the limitations were: 1) detailed procedure analysis is costly, 2) technicians resist using a fully algorithmic approach, 3) the algorithms are very situation specific and thus expensive to update, 4) retention of algorithm details is a constant problem, and 5) transfer of troubleshooting skills to new systems or new faults is relatively low.

Foshay's (1987) research used knowledge approach to design instruction. Both declarative and procedural knowledge are subsumed into a single rule structure. Expert knowledge, including heuristic knowledge and domain specific knowledge, is the best model for
minimizing the novices learning time. The instructional strategies he suggested were: 1) teach the symbol system used to represent the problem, 2) teach the system under study, including both its components and their causal relationship, 3) identify the failure modes of each type of system component, 4) teach algorithms for isolating each type of component failure, and 5) teach heuristics for troubleshooting the system in general. These strategies are in accord with Harmon's (1986) teaching strategy.

For computer-centered teaching strategy, Feurzeig and Ritter (1987) developed a QUEST simulator for interactive learning activities. Every time, the monitor posed the question to the student about what he/she learned from the test or measurement. This helps students yield extensive information about the theories and procedures as a foundation for making inferences about his/her misconception and debugging responses. It had been demonstrated as a valuable teaching strategy for troubleshooting instruction. This strategy can be helpful for teaching TV troubleshooting with the aid of a computer.

The effectiveness of computer-assisted instruction in laboratory work

Few research studies evaluated the effectiveness of implementing the microcomputer in school laboratory work. Some research results, such as the investigations done by Castro (1990), Steinick (1987), Taylor (1987), Trollip and Johnson (1982), and Knerr and Nawrocki (1978), showed that the microcomputer played an important role in student's studying processes. These researchers discovered significant
differences in student achievement when comparing computer-assisted instruction to conventional teaching methods. On the other hand, Morrison and Witmer (1983) found that there are no significant differences between computer-assisted instruction and conventional methods.

The results were somewhat inconclusive of studies regarding the comparison of computer-assisted instruction and traditional instruction. However, more research results are positive for computer-assisted instruction. The different conclusions are somewhat related to the way in which the researchers designed their studies. The hardware, software, and the personnel all contributed as variables in these results. The application of artificial intelligence techniques and computer simulation to laboratory instruction are better than paper work in the laboratory type of learning. It also saves much time and money for expensive training equipment such as aviation training, naval training, or technical courses requiring expensive equipment or requiring the operation of equipment with certain accident risks during the learning process.

The comparison of interactive video systems

After comparing video cassette, video disc, and digital video interactive educational systems, it is apparent that DVI is the best choice for high quality interactive systems. DVI can bring audio, video, and the personal computer together to create a powerful information system with vast storage capacity for educational purposes.
More educational media will be replaced by the production of DVI technology.

According to Luther's (1989) research, digital video refers to a system where all of the information that represents images are in some kind of computer data form, which can be displayed or manipulated by a computer. The final purpose of DVI technology is to enable every user an application of this technology to every needed place if he/she knows how to key in simple instructions. The most significant feature of DVI is its frame-based data processing model. It can merge text and color images on a single monitor. The user can edit any picture or graph on it and can change the data already set-up. Thus, it is more flexible than video discs for most cases.

Currently, video discs are the best media for fixed teaching material. Luppa (1988) stated that the video disc is the most economical media for the total interactive learning system. It is better than video cassettes and less expensive than DVI production. However, DVI production is the most flexible media to meet most educational environments. Since educational technology is becoming more computerized and the all-digitalized capability is becoming the main stream in the information century, DVI can be a prospective contributor for the education system.

The expert system for intelligent instruction

In order to use DVI technology in the educational environment, it is helpful to know how to develop an available software for DVI
hardware, especially for developing courseware for teaching TV troubleshooting. Kearsley (1987) depicted five major paradigms for developing an intelligent tutoring system. Johnson (1987) investigated the knowledge and skill differences between expert and novice service technicians on technical troubleshooting tasks. The model that he designed is useful for developing an expert system. It includes cognitive knowledge and learning experiences.

Clancey (1987) and his colleagues developed an intelligent tutoring system for teaching medical diagnoses. The methodology proved to be a practical help for designing a tutoring system. They stated that too often experimental analysis seems to fall short by not being precise enough to be programmable. This is the problem that limits the flexibility of a fixed program. The simplification may eliminate the very points that are needed to build a working system.

Woolf et al. (1986) analyzed knowledge into four types for an expert system. All declarative, procedural, heuristics and simulation rules are needed for a quality expert system. The effectiveness of good courseware must provide clear knowledge in short text, quality interaction, and a visible structure. Basically, the structure of the courseware for teaching technical troubleshooting is nothing less than an expert system.

The review of the literature provided to the researcher several insights into the complexities of creating an expert system; the limitations of particular systems, and research methodology.
shortcomings. There are many variables which enter into a carefully designed research problem, if ignored can invalidate the research results. Inconclusive findings generally stem from research designs which have ignored the very critical variables that influence outcomes or analyses which fail to control the interactive effects.

All the literature cited was useful to the researcher to recognize the progress being made in TV troubleshooting and the care that is needed to develop effective instructional systems.
CHAPTER III. METHODOLOGY

This chapter provides a description of the methods used to conduct this study. The description includes hypotheses, sampling subjects, research design, variables of the study, data collection instruments, and statistical analysis of the data.

Hypotheses of the Study

This study specifically tested the following null hypotheses:

Hypothesis 1: There was no significant effect of audio-video electronics scores upon the achievement scores in learning TV troubleshooting knowledge and skills.

Hypothesis 2: There was no significant effect of electronic instrument scores upon the achievement scores in learning TV troubleshooting knowledge and skills.

Hypothesis 3: There was no significant effect of CAI scores upon the achievement scores in learning TV troubleshooting knowledge and skills.

Hypothesis 4: There was no significant achievement difference between the two groups of students who studied TV troubleshooting knowledge by traditional method versus the DVI method.

Hypothesis 5: There was no significant achievement difference
between the two groups of students who studied TV troubleshooting skills by the traditional method versus the DVI method.

Hypothesis 6: There was no significant time consumption difference between the two groups of students for dealing with the same defective circuits, one group using the traditional method, while the other group using the DVI method.

Hypothesis 7: There was no significant achievement difference between junior and senior students in a university in learning TV troubleshooting knowledge and skills.

Hypothesis 8: There was no significant preference among the students of the experimental group in applying image database for TV troubleshooting instruction.

Sampling Subjects

The subjects used in this study were the junior and senior students enrolled in the Industrial Education Department of National Taiwan Normal University during 1989-1990 school year. They were all majoring in Electronic Techniques and already studied TV theory and troubleshooting skills during their vocational high school periods. The educational backgrounds of subjects of this study were equivalent to junior and senior undergraduate students in the United States.
All senior and junior students who majored in Electronic Techniques in the Industrial Education Department of National Taiwan Normal University were selected. Eighteen students were selected from junior classes and the other eighteen students were selected from senior classes. A total of thirty-six students were selected from the Industrial Education Department of National Taiwan Normal University. They were randomly divided into two groups in each class by random number table. Each group contained eighteen students. All the sampling methods and procedures in this study were approved by the Human Subject Review Committee at the Iowa State University.

Group I: An experimental group in which eighteen students formed nine subgroups and each subgroup consisted of two students used a microcomputer, a pattern generator and a multimeter to learn TV troubleshooting during class sessions.

Group II: A control group in which no computer is provided. Only traditional instruments (multimeter, oscilloscope, pattern generator, sweeper, marker and TV analyzer) are provided for learning TV troubleshooting. They are organized into nine subgroups and each subgroup consists of two students.
Research Design

The investigation focused on the achievement by the subjects who were exposed to two different methods of TV troubleshooting instruction. The pretest-posttest control group design was used in the experiment. This design is schematically presented as the following:

Group I  R  O  X  O
Group II  R  O  T  O

R stands for simple random selection of subjects
O stands for observation, either a pretest, posttest, or skill test
X stands for experimental treatment
T stands for traditional treatment

Variables of the Study

The following independent variables were studied:
1) Audio-video electronic scores from the previous semester
2) CAI application experience
3) Electronic instrument scores from the previous semester
4) Pretest scores

The following dependent variables were studied:
1) The subject's achievement of TV troubleshooting knowledge
2) The subject's achievement of TV troubleshooting skills
3) The time spent for troubleshooting a defect in a TV set
Data Collection Instrument

The audio-video electronic score and electronic instrument score were gathered through school records. The CAI scores for senior students who had previously taken this course were gathered through school records too. The pretests were designed for assessing the subject's knowledge level for doing TV troubleshooting.

The achievement instrument was designed to measure how well the subjects had learned TV troubleshooting knowledge and skills. The knowledge and skills included:

1. understanding the functions of every block circuit in a TV set,
2. understanding how to trace a defective component,
3. using test patterns correctly, and
4. troubleshooting with less time.

In order to reach a high reliability of the instrument, items were selected from the NHK Electrician Standard Test which was used as the norm test for vocational training in Taiwan. Each item was selected from the categories of low, medium, and high difficulties with an equal number of questions. Therefore, the difficulties of pretest and posttest were within the same level.

In addition to the theory questions of TV troubleshooting, the recognition question of TV test patterns was also given in both the pretest and the posttest. The items for the skill test were chosen from the service manual of Z-20A color TV which was the TV model most
often used for school laboratory instruction in the National Taiwan Normal University. The pretest, posttest, and skill test questions are listed on Appendixes B, C, D, E, and F.

**Procedure of the Experiment**

The experimental process included the following activities:

1. Obtained the permission from the students and their teachers for doing the experiment. This procedure was approved by the Human Subjects Review Committee at the Iowa State University on April 2, 1990.

2. Students were randomly assigned into two groups. They were not told the experimental plan until the end of the data collection process. Students in each group were told to rotate in turn three weeks later, which means that, after three weeks, students switched from one group to another. This strategy eliminated the threat of the Hawthorne Effect and the John Henry Effect.

3. A pretest was conducted during the first meeting before the teaching process began. It took thirty minutes and was given to both groups at the same time, but at different classrooms.

4. A two-hour lecture was given to Group I for introducing DVI technology immediately after the pretest. In the meantime,
a two-hour lecture was given to Group II for introducing traditional television troubleshooting methods. Each group was taught by different teachers.

5. Both groups studied the same knowledge units but with different methods. The learning units are listed in the next chapter.

6. Both groups studied the actual TV troubleshooting skills. Group I were asked to become familiar with the DVI courseware. Whereas, Group II were asked to become familiar with traditional TV troubleshooting methods.

7. Both Group I and Group II were given a posttest at the end of the experiment for checking the knowledge achievement.

8. Both Group I and Group II were given a skill test after the knowledge test. The skill test consisted of troubleshooting vertical circuits, horizontal circuits, and color circuits of Z-20A color TV set. The time each student spent for the skill test was recorded as speed score for the total score.

9. A questionnaire was given to Group I for surveying the student's response to the DVI courseware after the experiment.
Statistical Analysis of the Data

To control for error and increase precision, multiple covariance analysis was used to test the equality of achievement between the two groups of students. The following procedures were used to analyze the data collected in this study:

1. A multiple covariance analysis using the GLM (General Linear Model) procedure with the aid of a SAS package was used to evaluate the effects of previous grades from Audio-Video Electronics and Electronic Instrument classes, and the CAI class.

2. The hypotheses that no significant effects of Audio-Video Electronics score, the Electronic Instrument score, and the CAI application experience were found in reference to the achievement test scores.

3. A t-test was used to test the significance of Group I and Group II by the adjusted group means.

4. Analysis of variance was used to analyze achievement of every student in each group.
CHAPTER IV. THE DEVELOPMENT OF THE COURSEWARE

The courseware developed for this study is to provide students with knowledge and skills, and to guide them in the development of expertise for TV troubleshooting instruction. Since the major content of TV troubleshooting is decision-making, the most available teaching model for this course would be the "problem-solving model." It includes many reasoning and decision-making processes that can be solved with AI techniques. Among the various fields of AI, the Expert System (ES) has the greatest potential for education. It is the most popular form of AI in education and can be used as a tool (e.g., decision aids), tutors (e.g., intelligent tutoring systems), and the role of tutees (knowledge engineering).

According to the literature review, there are five paradigms that make up the ICAI (Intelligent Computer-Assisted Instruction). [Note: Expert System is the newest form of ICAI]. Among them, the expertise module can be the best type to teach TV troubleshooting, because the expertise module is used to generate instructional content and to evaluate the student's performance. The domain knowledge is organized within the structure of a computer program for the flexible manipulation of the data in the teaching and learning processes. In the expertise module, production systems are used to construct modular representations of skills and problem-solving methods. The basic idea of production systems is that the knowledge database consists of rules, called productions, in the form of condition-action pairs as follows:
"If <this> condition occurs, then do <this> action."

For a complete expertise module, it also is necessary to develop a clear semantic network and procedural representations, and the building of script-frames. Thus the major procedures of the development of this courseware consist of the following steps:

1. Collecting expert knowledge for TV troubleshooting

2. TV troubleshooting analysis

3. Identifying logical control rules

4. Sequencing system flow-chart

5. Organizing system hardware

6. Organizing system software and coding

7. System testing

8. System refining

Collecting Expert Knowledge for TV Troubleshooting

In order to develop a knowledge base for instructing television troubleshooting, obtaining sufficient information from television troubleshooting experts and TV engineering instructors is needed. The main information sources are:

1. Literature
2. Experts

3. Examples

Literatures

There are several literatures for TV troubleshooting:

1. Textbooks for television theory and servicing
2. Television servicing handbooks
3. Specific TV troubleshooting manuals
4. Periodicals for TV servicing technicians

The information obtained from the above sources are more scientific than the other two sources. They are organized in a regular structure and it is easy to find the rules they follow to solve the troubles they incur.

Experts

It is more difficult to organize several expert's knowledge about TV troubleshooting. Their experiences make them subconsciously diverse about something they learned before. However, the theory of the TV receiver system is almost the same for different types of TV sets. Hence, the knowledge of TV troubleshooting experts can still be clearly organized with certain regularities.

The methods used for obtaining expert's knowledge included: interview, letter, and telephone questioning. After interviewing the experts, the records were kept for analysis. The TV experts who took part in this research were the managers of the service departments in the companies of Tatung, Taiwan Sanyang and Sharp in Taiwan.
Examples

There are some databases of examples that can be employed with an induction technique to this study. For example, an expert system that diagnoses soy bean diseases can be employed in other diagnostic cases.

It is feasible to apply induction rules to TV troubleshooting instruction design. The knowledge that is used to solve television troubleshooting problems was based on experience and observation. It included empirical and heuristic rules that did not have the same power of laws as in other cases. The example for some specific cases can not be applicable for all other cases. The examples that were used as a reference for this study were "The expert system model for maintenance and staff training" and the "QUEST system." However, they were not fully suitable for the system development on TV troubleshooting instruction courseware, because of the different strategies that were used to reach the goals.

The Analysis of TV Troubleshooting Rules

After collecting expert knowledge from the service manual, TV engineering textbook, and interviewing the TV experts, the analysis of the troubles and troubleshooting methods were organized into the following categories.


TV symptoms

In general, the TV troubles can be addressed as following 44 symptoms, each with one or several causes as followed.

1. Dead set:
   1) Low voltage power supply breakdown
   2) Horizontal deflection circuit breakdown

2. No raster:
   1) Video amplifier breakdown
   2) Horizontal deflection circuit breakdown
   3) Automatic brightness limiting circuit breakdown

3. No vertical deflection:
   1) Vertical deflection circuit breakdown

4. No vertical synchronization:
   1) Integrated circuit breakdown
   2) Vertical oscillator circuit breakdown

5. Insufficient vertical deflection and poor linearity:
   1) Vertical deflection circuit breakdown

6. Fold-over:
   1) Vertical deflection circuit breakdown (vertical fold-over)
   2) Horizontal oscillator circuit breakdown (horizontal fold-over)

7. Improper synchronization:
   1) Vertical oscillator circuit breakdown (improper vertical sync)
2) AFC detector circuit breakdown (improper horizontal sync)

8. No horizontal and vertical synchronization:
   1) Sync separator circuit breakdown
   2) Sync amplifier circuit breakdown
   3) Noise cancelling AGC circuit breakdown

9. No horizontal synchronization:
   1) AFC amplifier circuit breakdown
   2) Horizontal oscillator circuit breakdown

10. Part of image is out of synchronization:
    1) Sync separator breakdown
    2) AGC circuit breakdown

11. Insufficient horizontal deflection:
    1) Horizontal deflection sawtooth circuit breakdown
    2) Low B+ voltage

12. Wavy vertical edges:
    1) AFC misadjustment
    2) AFC phase-detector output circuit breakdown

13. Christmas-tree effect (horizontal trigger oscillation):
    1) De-tuned horizontal stabilizing circuit breakdown

14. No image:
    1) Video amplifier circuit breakdown (with sound)
    2) Local oscillator circuit breakdown (without sound)
15. Weak contrast:
   1) Tuner circuit breakdown
   2) Antenna circuit breakdown

16. No reception in a particular channel:
   1) Local oscillation frequency shift for that channel

17. Negative contrast:
   1) AGC circuit misadjustment

18. Image interference from other stations:
   1) RF amplifier circuit overloading

19. White dots on the screen:
   1) Noise cancelling AGC circuit breakdown

20. No color:
   1) Bandpass amplifier breakdown
   2) ACC breakdown
   3) Color killer misadjustment
   4) 3.58MHz oscillator breakdown
   5) Burst gate and burst amplifier breakdown

21. No color synchronization:
   1) Burst gate circuit breakdown
   2) 3.58MHz oscillator circuit breakdown

22. Improper color:
   1) Hue control misadjustment
2) Detuning of the color synchronization circuit breakdown

23. Loss of one or two primary colors:
   1) Color demodulator breakdown
   2) Color amplifier circuit breakdown
   3) Color subtraction amplifier circuit breakdown

24. Weak color:
   1) AGC circuit breakdown
   2) Bandpass amplifier breakdown
   3) Fine-tuning circuit poorly tuned

25. Nonuniform color strength:
   1) Local oscillator frequency drift
   2) Color killer misadjustment
   3) Mismatch between the antenna and the feeder cable

26. Poor color purity:
   1) Magnetized shadow mask
   2) Poor color purity adjustment

27. Poor convergency all over the screen:
   1) Misadjustment of the static convergence magnet

28. Poor convergence on the sides of the screen:
   1) Horizontal convergence circuit breakdown
   2) Flyback coil open circuit

29. Colored raster:
1) Poor white balance adjustment
2) Color demodulation circuit breakdown

30. Color smear:
   1) Bandpass amplifier circuit response decreased
   2) Color subtraction amplifier circuit breakdown

31. Fine color noise: (during black-and-white reception)
   1) Color killer misadjustment
   2) Bandpass amplifier disabled during B&W reception

32. Poor brightness:
   1) High voltage circuit breakdown
   2) Horizontal deflection circuit breakdown
   3) CRT circuit breakdown

33. A bright spot in the middle of the screen:
   1) ABL circuit breakdown
   2) Both vert. and hor. deflection circuits breakdown (seldom)

34. Appearance of the retrace lines:
   1) Vertical blanking circuit breakdown

35. Poor focus:
   1) Focus circuit breakdown
   2) High-voltage rectifier breakdown
   3) White balance misadjustment
   4) Fine-tuning circuit misadjustment
36. Periodic raster movement:
   1) Low voltage regulator circuit breakdown

37. Black horizontal bars on the screen:
   1) Low voltage regulator circuit breakdown
   2) CRT cathode and the filament leak

38. Warped raster:
   1) Pin-cushion circuit breakdown

39. No sound:
   1) Sound circuit breakdown

40. Weak sound:

41. Buzzing sound:
   1) Misadjustment of the AGC control
   2) Misalignment of the sound-detector transformer

42. Distorted sound:
   1) SIP amplifier detuned circuit breakdown
   2) Sound-detector circuit breakdown

43. Noisy sound:
   1) Sound output transformer
   2) Resistor partially open

44. Color noise:
   1) Misadjustment of the fine-tuning circuit
2) Misalignment of the sound traps in the VIF circuit
3) Misalignment of the sound trap after the video detector

The classification of TV symptoms

TV symptoms can be categorized with the effect on raster, picture, sound, and color if a stage becomes defective. Because the TV signal is composed of raster (deflection background), picture (BW signal), color (paint signal), and sound signal, the major 44 defective symptoms or the total 265 symptoms of the transistor/IC type TV can be classified into the following fewer classifications with these four factors. And each factor can be subdivided into more than one subfactors as follows:

1. Raster:
   1) O.K.
   2) No raster
   3) Blooming
   4) No vertical deflection (one horizontal line)
   5) Vertical foldover
   6) Poor vertical linearity
   7) Horizontal foldover
   8) Poor horizontal linearity
   9) Loss of width
   10) Pincushion distortion
   11) Retrace lines visible
2. Picture:
   1) O.K.
   2) No picture
   3) Weak picture
   4) Negative picture
   5) Loss of vertical sync
   6) Loss of horizontal sync
   7) Loss of both vertical and horizontal sync
   8) Poor dynamic convergence
   9) No channel selection
   10) Picture reach CRT but deformed
   11) Piecrust distortion (ringing)
   12) Others

3. Color:
   1) O.K.
   2) No color
   3) Weak color
   4) Excessive color
   5) Loss of color sync
   6) Wrong colors
7) Colored raster
8) No automatic color control
9) Others

4. Sound:
   1) O.K.
   2) No sound
   3) Buzz
   4) Weak sound
   5) No sound control
   6) Others

For example, the symptoms of a dead set can be described as the combination of 1) no raster, 2) no picture, 3) no color, and 4) no sound. The symptom of "No raster" can be described as the combination of 1) no raster, 2) no picture, 3) no color, and 4) sound is normal. That is, every symptom can be described as the combination of the conditions of raster, picture, color, and sound. Hence, these four items can be used as the criteria for troubleshooting decision-making. It is not difficult for students to recognize every subfactor.

The other reference data that can be helpful for television troubleshooting are those contained in the statistical table issued by a television manufacturer. Table 3 shows the trouble occurring frequency of the Z-20A color TV receiver issued by the Taiwan Sharp Company.
TABLE 3. Trouble occurrence frequency in a typical TV set

<table>
<thead>
<tr>
<th>Circuit Stage</th>
<th># of symptoms</th>
<th>Percentage(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal circuit</td>
<td>48</td>
<td>18.1%</td>
</tr>
<tr>
<td>Vertical circuit</td>
<td>44</td>
<td>16.6%</td>
</tr>
<tr>
<td>Video amplifier circuit</td>
<td>38</td>
<td>14.3%</td>
</tr>
<tr>
<td>Tuner</td>
<td>34</td>
<td>12.8%</td>
</tr>
<tr>
<td>Power supply</td>
<td>26</td>
<td>9.8%</td>
</tr>
<tr>
<td>Color circuit</td>
<td>24</td>
<td>9.1%</td>
</tr>
<tr>
<td>VIF amplifier</td>
<td>17</td>
<td>6.4%</td>
</tr>
<tr>
<td>Sound circuit</td>
<td>16</td>
<td>6.0%</td>
</tr>
<tr>
<td>Remote controller</td>
<td>13</td>
<td>5.0%</td>
</tr>
<tr>
<td>CRT circuit</td>
<td>5</td>
<td>1.9%</td>
</tr>
<tr>
<td>Total</td>
<td>265</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Symptoms shown on the test pattern diagram

Another helpful method for troubleshooting a defective circuit is looking at the test-pattern image on the screen. It is similar to a "complexion diagnosis" for disease determination. The experienced doctor can diagnose the nature of a disease by observing the appearance of a sick person. Similarly, an experienced TV troubleshooter can easily understand the causes of a trouble by looking at the image shown on the CRT. If the meaning of a normal pattern and the corresponding defective symptoms are known, it is feasible to make a right decision for troubleshooting.
The conventional TV test-pattern are shown as Figures 8 and 9. Figure 8 is used on commercial TV programs. It is often transmitted to the user's TV receivers at the beginning of the daily program, and used as the standard for users to adjust control knobs to have a normal reproduction of the picture. However, not every user understands the meaning of the test-pattern. Figure 9 is a simplified diagram that is used in the lab as a test signal and is provided by a television analyzer.

A test-pattern is more informative than a simple bar signal because the details of test-pattern reproduction indicate various kinds of circuit malfunction. For example, if low-frequency phase shift is indicated, the low-frequency response of the picture channel is subnormal, a video-amplifier coupling or decoupling capacitor might be defective. Blurred vertical wedges in the pattern indicate that the picture channel bandwidth is deficient, a component defect in the IF amplifier may be upsetting resonant-circuit response.

There are other test-patterns used, but most of them include circles, diagonal lines, horizontal wedges, vertical wedges, bars, shading blocks, and resolution lines. The meaning of these items are listed as follows:

1. Circles denote "picture size", "linearity", and "centering."

2. Horizontal wedge indicates "vertical resolution."

3. Vertical wedge indicates "horizontal resolution."
FIGURE 8. Information provided by a standard test-pattern

4. Diagonal lines indicate "interlace."

5. Bars indicate "low frequency phase shift."

6. Shading blocks indicate "brightness", "contrast", and "AGC."
FIGURE 9. A simplified test-pattern for TV troubleshooting

7. Resolution lines indicate "high frequency ringing."

8. Calibration numbers indicate "resolution in lines."

The test-pattern is a very useful tool to diagnose a television set. It can be decomposed into several different signals and generated by the dot-crosshatch-color-bar generator. In the dot mode, the
generator develops signals that produce a pattern of uniformly-spaced white dots on the picture tube screen. In the crosshatch mode, a pattern of white lines is produced. Either may be used for checking and adjusting the beam convergence of a set. The generator alternately turns the three beams of the CRT on and off a number of times during each vertical and horizontal scan. If the triads of the three fields exactly overlap while the beams are on, the dots will be white, i.e., perfect convergence. Where there is misconvergence on portions of the screen, the dots in those areas will show color. Convergence adjustments are made as needed until there is no color visible on either pattern.

A color-bar generator develops signals that display a pattern of vertical color bars on the screen. There are usually ten bars of different hues, from yellow-orange on the left, through orange, red, magenta, reddish blue, blue, greenish blue, cyan, bluish green, to green on the right. Each color corresponds to a specific phase angle. The pattern is used for checking chroma stages, evaluating color reproduction, and making adjustments. If a receiver is operating properly, all hues will be displayed in their proper sequence and with the correct degree of saturation. Troubles are indicated when one or more colors are weak, missing, or out of sequence.

There are three types of color-bar generators: 1) rainbow generator, 2) keyed-rainbow generator, and 3) NTSC color-bar generator. Among them, the NTSC color-bar generator develops fully saturated bars
of the precisely correct hues in accordance with NTSC standard.
Different signal amplitudes ensure identical brightness levels for all
colors. It is the best color signal source for troubleshooting NTSC
color TV receivers and was selected as the test standard for this
research.

The Analysis of Control Rules for Expert System

Many knowledge-based expert systems use rule-based representation
technology to formulate the systems. In most cases, rules are
conceptually represented as IF/THEN statements with the logical form
expressed as:

IF <predicate> THEN <consequent>

Using such statements, we can formulate the knowledge that we
obtain from the experts into sets of such rules. The inference engine
then analyzes and processes these IF/THEN rules in one of two ways:
backward or forward. In backward-chaining, the inference engine works
backward from hypothesized consequents to locate known predicates that
would provide support. In forward-chaining, the inference engine works
forward from known predicates to derive as many consequents as
possible. For the case of TV troubleshooting, since the knowledge base
already exists with values such that the predicates would evaluate to
'TRUE'. A forward-chaining engine can be used in this research. That
is, a goal is pursued starting from a set of facts. Operating in this
way, the events drive the system toward the goal.
The rules for TV troubleshooting

According to the symptom analysis outlined in the previous sections, the control rules for TV troubleshooting can be stated as follows:

Rule 1: IF no raster
AND no picture
AND no color
AND no sound
THEN breakdown (power supply)
OR breakdown (horizontal deflection circuit)

Rule 2: IF one horizontal line in the middle of the raster
AND loss of vertical sync
AND color is O.K.
AND sound is O.K.
THEN breakdown (vertical deflection)

Rule 3: IF colored raster
AND no other symptom known
THEN misadjustment (white balance adjustment)

It is possible to draw a flow-chart for control structures for the above rules. Figure 10 and Figure 11 show the organizations of the
troubleshooting logics. There are two types of decision-making structures in these two figures. One is IF-AND-THEN-OR with successive selections shown in Figure 10, the other is IF-THEN with alternative selections shown in Figure 11. The first logic depicts the most common structure and the later logic depicts the unusual cases.

IF R1 AND P1 AND C1 AND S1 THEN X1 OR X2

FIGURE 10. The IF-AND-THEN-OR logic for TV troubleshooting
FIGURE 11. The IF-THEN logic for TV troubleshooting

The tree structure for the troubleshooting system

Basically, the TV troubleshooting training system includes "symptoms input", "failure diagnosis", "knowledge based expert system", and "images base." The knowledge based expert system supports the first two parts, and the images base support the failure diagnosis. The system organization is illustrated as Figure 12.
Applying the Four-Factor Diagnosis (FFD) method, i.e., use raster, picture, color, and sound four criteria to judge the symptoms, then the tree structure for the troubleshooting system can be created as illustrated in Figure 13. Suppose that every factor is independent.
from selected other factors, it is possible to put any factor at the root place. And it is possible to add some more items under any factor if needed.

If a technician uses a test-pattern to help the diagnosis, it is possible to check the CRT picture first then use tree structure logic for decision-making. Thus, the time spent for diagnosis would be shorter.

Troubleshooting System Organization

The major task of this study was to develop an expert system, a microcomputer-aided instruction courseware with digital image display ability. It is an interactive image system, which interfaces a computer with a CCD camera, and composite monitor. The sequence, rate of presentation, and condition of the image base display are under direct control of the computer program. Thus, the computer is used to teach, query, remediate, and otherwise support the visual lesson.

Hardware organization

The hardware configuration of this interactive image system is shown in Figure 14. It includes the following four components:

1. IBM PC/AT microcomputer:
   - CPU 80386-25MHz
   - 4M RAM
   - 64K Cache
   - 84 MB SCSI hard disk
FIGURE 13. The tree structure of TV troubleshooting

- One 1.2 MB floppy disk
- Enhanced 101 keyboard
- AMI BIOS
- VGA display & card

2. Frame Grabber (CFG-512N)
• Accept NTSC color composite video signal
• Output NTSC color composite video signal
• Screen resolution: 512x512 pixels
• Pixel colors: R,G,B, each with 5 bits, providing 32768 colors
• Frame memory: 512K bytes
• Address space: 64K bytes
• Digitization rate: 1/30th second per frame (NTSC)
• Hardware zoom: 2X, 4X, and 8X magnification
• Hardware pan and scroll: double pixel pan and double line scroll

3. CCD camera (CCD-F45):
• Video recording system: helical scanning FM system
• Audio recording system: rotary head, FM system
• Video signal: NTSC color, EIA standards
• Usable cassette: 8 mm video format cassette
• Image device: CCD
• Viewfinder: electronic viewfinder
• Lens: combined 8 X power zoom lens
• Focus: auto focus system
• Color temperature: auto, indoor 3,200K; outdoor 5,800K
• Minimum illumination: 3 lux
• Illumination range: 3 - 100,000 lux
• Aperture correction: automatic

4. Mouse (Logitech serial-PS/2 version):
• With 25-to-9 pin extension cable that connects to IBM AT serial ports
• Require 256K RAM for mouse, 384K when using Pop-Up DOS
• Requires DOS 3.3 or later revision
• Graphics adapter: monochrome, hercules, CGA, VGA and enhanced graphic adapter with enhanced color monitor
• Drives: two floppy disk drives, or a hard disk and one floppy disk drive
• Port: serial port COM1 or COM2

5. Multisync color monitor:
• Resolution 800 X 600
• Frequency 15.5 - 35KHz
• Analog video input
• Unlimited on-screen color
• 14" nonglare display

Software organization

The system software of TV troubleshooting instruction consists of three components, namely a knowledge base, an image base, and an inference engine. The knowledge base includes a library of decision-making rules, frames of troubleshooting procedures, and the frames of learning units. The image base contains test patterns, block diagrams, stage circuits, and symptomatic pictures. The inference engine includes frame and rule interpreters, user commands, and screen interface. Figure 15 illustrates the architecture of this expert system.
FIGURE 14. Overall structure of the system hardware

When the user initiates this expert system, the knowledge base will generally consist solely of the frames of learning units that are displayed within a window and work in the interactive mode. As user input is received by the system, the inference engine will provide the uniform access to the components of the system and give guidance to the user in the construction of courseware. It will help also the user...
FIGURE 15. The architecture of TV troubleshooting expert system

conceptualize a problem. At each step, the necessary concepts and procedures can be shown to the user.

In order to simplify the interactive response activity, a menu structure is used to provide the conditions about every decision-making activity. The interface is not context-sensitive and relies on the user making the right selection. If the selection is an image, the
The inference engine will load the image to the screen. The main menu contains "Database Access/Reporting", "Create/Alter Database", "PAL Development", "Utilities", "Alter System Defaults", "Select New Database", and "Exit" according to the structure of commercial PC Album's forte. The editing operation procedures are shown in Appendix 0.

Its driver has been written for the PC mouse from Logictech Corp. Thus the user can move the cursor to the answer code and click the left button of the mouse to call for an answer.

**Decision-making rules**

The decision-making rules were organized with 'IF-THEN' logic as described in the last section. For the availability of logic operation, every trouble condition was encoded in alphanumeric code, and the symptoms were encoded also in the same way as follows:

1. Encoded trouble conditions

**Raster:**

R1 -- raster is O.K.
R2 -- no raster
R3 -- blooming
R4 -- no vertical deflection (one horizontal line)
R5 -- insufficient height
R6 -- poor vertical linearity
R7 -- horizontal foldover
R8 -- poor horizontal linearity
R9 -- loss of width
R10 -- pincushion distortion
R11 -- retrace lines visible
R12 -- rolling
R13 -- keystone
R14 -- others

Picture:

P1 -- picture is O.K.
P2 -- no picture
P3 -- weak picture
P4 -- negative picture
P5 -- loss of vertical sync.
P6 -- loss of horizontal sync.
P7 -- loss of both vertical and horizontal sync.
P8 -- poor dynamic convergence
P9 -- no channel selection
P10 -- picture reach CRT but deformed
P11 -- piecrust distortion (ringing)
P12 -- others

Color:

C1 -- color is O.K.
C2 -- no color
C3 -- weak color
C4 -- excessive color
C5 -- loss of color sync.
C6 -- wrong color
C7 -- colored raster
C8 -- no automatic color control
C9 -- poor color purity
C10 -- others

Sound:
S1 -- sound is O.K.
S2 -- no sound
S3 -- buzz
S4 -- weak sound
S5 -- no sound control
S6 -- others

2. Symptom diagnosis rules

Part 1: Vertical sweep section

Rule V1: IF R4 is true
        AND P10 is true
        AND C8 is true
        AND S1 is true
THEN Vert. OSC. is defective
OR Vert. driver is defective
OR Vert. output is defective
AND The troubleshooting procedure is TPV1

Rule V2: IF R5 is true
AND P10 is true
AND C1 is true
AND S1 is true
THEN Vert. output is defective
OR Vert. sawtooth-forming circuit is defective
AND The troubleshooting procedure is TPV2

Rule V3: IF R6 is true
AND P10 is true
AND C1 is true
AND S1 is true
THEN Vert. OSC. is defective
OR Vert. driver is defective
OR Vert. negative feedback circuit is defective
AND The troubleshooting procedure is TPV3

Rule V4: IF R13 is true
AND P5 is true
AND C1 is true
AND S1 is true
THEN Vert. OSC. is defective
OR Vert. integrator is defective
AND The troubleshooting procedure is TPV4

Rule V5: IF R11 is true
AND P1 is true
AND C1 is true
AND S1 is true
THEN Vert. retrace blanking circuit is defective
OR Brightness circuit is misadjusted
AND The troubleshooting procedure is TPV5

Rule V6: IF R10 is true
AND P10 is true
AND C1 is true
AND S1 is true
THEN Vert. yoke coil is defective
OR Pincushion coil is defective
AND The troubleshooting procedure is TPV6

Part 2: Horizontal sweep section

Rule H1: IF R2 is true
AND P2 is true
AND C2 is true
AND S1 is true
THEN Horiz. Output is defective
OR High voltage supply is defective
OR CRT heater is defective
AND The troubleshooting procedure is TPH1

Rule H2: IF R9 is true
AND P1 is true
AND C1 is true
AND S1 is true
THEN Horiz. output transistor is defective
OR Horiz. OSC. is defective
OR Horiz. B voltage is defective
AND The troubleshooting procedure is TPH2

Rule H3: IF R12 is true
AND P6 is true
AND C1 is true
AND S1 is true
THEN Horiz. OSC. is defective
OR AFC is defective
AND The troubleshooting procedure is TPH3

Rule H4: IF R7 is true
AND P10 is true
AND C1 is true
AND S1 is true
THEN Horiz. output is defective
OR Horiz. driver is defective
AND The troubleshooting procedure is TPH4
Rule H5: IF R2 is true
AND F2 is true
AND C2 is true
AND S2 is true
THEN Horiz. output is defective
OR Horiz. OSC. is defective
OR Low voltage power supply is defective
AND The troubleshooting procedure is TPH5

Rule H6: IF R10 is true
AND F10 is true
AND C1 is true
AND S1 is true
THEN Horiz. deflection yoke is defective
AND The troubleshooting procedure is TPH6

Rule H7: IF R1 is true
AND F11 is true
AND C1 is true
AND S1 is true
THEN Horiz. OSC. is defective
OR AFC is defective
AND The troubleshooting procedure is TPH7

Part 3: Chroma section
Rule K1: IF R1 is true
AND P1 is true
AND C2 is true
AND S1 is true
THEN BPA is defective
OR ACC is defective
OR Color killer is defective
OR Color demodulator is defective
OR Comb filter is defective
AND The troubleshooting procedure is TPK1

Rule K2: IF R1 is true
AND P1 is true
AND C3 is true
AND S1 is true
THEN BPA is defective
OR Color burst OSC. is defective
OR ACC is defective
AND The troubleshooting procedure is TPK2

Rule K3: IF R1 is true
AND P1 is true
AND C4 is true
AND S1 is true
THEN Color killer is defective
OR BPA is defective
OR Video IF is defective
AND The troubleshooting procedure is TPK3

Rule K4: IF R1 is true
AND P1 is true
AND C5 is true
AND S1 is true
THEN Burst gate is defective
OR APC is defective
OR 3.58MHz OSC. is defective
AND The troubleshooting procedure is TPK4

Rule K5: IF R1 is true
AND P1 is true
AND C7 is true
AND S1 is true
THEN Color killer is defective
OR APC is defective
AND The troubleshooting procedure is TPK5

Rule K6: IF R1 is true
AND P1 is true
AND C6 is true
AND S1 is true
THEN Color demodulator is defective
OR Color output amplifier is defective
OR 3.58MHz OSC. is defective
AND The troubleshooting procedure is TPK6

Rule K7: IF R1 is true
AND P1 is true
AND C8 is true
AND S1 is true
THEN Burst gate is defective
OR ACC is defective
AND The troubleshooting procedure is TPK7

Rule OUT: IF Rn, Pn, Cn, Sn doesn't match above combination
THEN Output 'This case will be covered in the next version'

Encoded troubleshooting procedure

Part 1: Vertical sweep section

TPV1: (for V1 — one horizontal line on the middle of the screen)
1. Turn down brightness so it will not burn CRT screen
2. Check B voltage for Vert. sweep section
3. Check Vert. OSC. output waveform
4. Check Vert. drive waveform

TPV2: (for V2 — loss of height)
1. Check the trapezoidal wave at vertical output point
2. Check R/C components in sawtooth-forming circuit
3. Check anti-ringing diode in vertical output circuit
TPV3: (for V3 -- poor linearity)
1. Check B voltage for vertical sweep circuit
2. Check Vert. OSC. waveform
3. Check vertical driver

TPV4: (for V4 -- loss of vertical sync.)
1. Check the frequency of Vert. OSC.
2. Check capacitor leakage
3. Check resistor values
4. Check transistor leakage

TPV5: (for V5 -- vertical retrace line visible)
1. Check brightness adjustment control
2. Check retrace blanking circuit

TPV6: (for V6 -- vertical keystone raster)
1. Check yoke coil (open or short)
2. Check pincushion coil
3. Check damping resistor across one yoke coil

Part 2: Horizontal sweep section

TPH1: (for H1 -- no raster but sound is O.K.)
1. Check CRT heater
2. Check high voltage
3. Check horizontal output voltage
TPH2: (for H2 — loss of width)
   1. Check B voltage for horizontal sweep section
   2. Check wave amplitude of horizontal OSC.
   3. Check horizontal output transistor

TPH3: (for H3 — loss of horizontal sync.)
   1. Check horizontal OSC. frequency
   2. Check AFC phase

TPH4: (for H4 — horizontal foldover)
   1. Check R/C in horizontal output circuit
   2. Check R/C in the driver decoupling filter circuit

TPH5: (for H5 — dead set)
   1. Check horizontal output transistor
   2. Check low voltage power supply
   3. Check horizontal OSC. output

TPH6: (for H6 — horizontal keystone raster)
   1. Check horizontal yoke windings

TPH7: (for H7 — piecrust picture distortion: ringing)
   1. Check the phase of the horizontal deflection sawtooth
   2. Check horizontal driver

Part 3: Chroma section

TPK1: (for K1 — no color but BW picture is O.K.)
1. Check BPA signal
2. Check color killer
3. Check ACC
4. Check 3.58MHz OSC. voltage
5. Check color demodulator output voltage

TPK2: (for K2 -- weak color)
1. Check BPA output voltage
2. Check 3.58MHz OSC. voltage
3. Check ACC signal

TPK3: (for K3 -- excessive color)
1. Check color killer
2. Check ACC signal
3. Check BPA voltage
4. Check Video IF signal

TPK4: (for K4 -- loss of color sync.)
1. Check 3.58MHz OSC. frequency and amplitude
2. Check color burst gate
3. Check color phase detector
4. Check APC signal

TPK5: (for K5 -- colored snow)
1. Check color killer threshold voltage
2. Check DC output voltage of phase detector

TPK6: (for K6 -- wrong color)
1. Determine which color is wrong
2. Check the demodulator of the wrong color
3. Check BPA signal
4. Check 3.58MHz OSC. phase
5. Check phase shift network

TPK7: (for K7 -- no automatic color control)
1. Check 3.58 MHz burst signal
2. Check ACC DC voltage
3. Check color killer DC voltage

Learning units
The learning units included in this experiment were organized in the following sequence:
1. Functions of block circuits
2. Functions of adjustment controls
3. Functions of test pattern
4. Major defective images
5. Vertical sweep section circuit
6. Horizontal sweep section circuit
7. Chroma sweep section circuit

Image database
The images were saved on the hard disk through frame grabber CFG-512N and can be displayed in an interactive way. Every image has its own filename in order to be easily remembered. There are three categories of images used in this experiment.
1. Block diagram
   1. TVBLOCK.tga — the block diagram of a whole set of color TV
   2. VERTBLK.tga — the block diagram of vertical sweep circuit
   3. HORIZBLK.tga — the block diagram of horizontal sweep circuit
   4. COLOBLK.tga — the block diagram of chroma circuit

2. Test pattern
   BIGPATN.tga — standard test pattern (including text comment)
   SMPPATN.tga — simplified test pattern

3. Symptomatic images
   1. VERTSYM1.tga — including V1 to V6 symptomatic images
   2. VERTSYM2.tga — including V5 to V6 symptomatic images
   3. HORIZSYM1.tga — including H1 to H4 symptomatic images
   4. HORIZSYM2.tga — including H5 to H7 symptomatic images
   5. COLSYM1.tga — including K1 to K4 symptomatic images
   6. COLSYM2.tga — including K5 to K7 symptomatic images

The language

The C language was chosen to design the driver interface program for its compatibility and fast accessibility. Since the image database was constructed with PC Album software and its PAL (Programmer Application Language) is a powerful programming language that extends the automatic facilities of the PC Album system, the courseware was coded with PAL. The explicitness of this language provides users the
availability of easy-to-modify, even if the user has no experience in C language.

The often used commands in this courseware were 'proc', 'define', 'display', 'input', 'move', 'set', 'repeat', 'until', and 'exit'. They were selected from the five categories of PAL commands: Definition Commands, Control and Data Movement Commands, Application Commands, Screen Commands, and I/O commands. There was no need to create any new command for this courseware.

For image frame grabbing, the CFGBAS package was applied to this courseware. It allows users to capture an object's image from camera or VCR, and edit the image with the editing tools of CFGBAS. It allowed also the user to paint on the image or create his/her own graphics on a computer with the 32,768 available colors. The commands of the video menu were 'scan/grab', 'window', 'adjust', 'resolution', 'equip config' and 'exit to main'.
of the knowledge representation still needs to be simplified. If the authoring tool can be achieved with a simple syntax, consistency, and completeness checkers to specialized editors, then this system will be a complete teaching expert system.
CHAPTER V. RESULTS AND FINDINGS

The primary purpose of this study was to compare the effectiveness of a microcomputer aided TV troubleshooting instruction using image database to that of the traditional instruction method. After a practical application of instruction, the results and findings were collected in this chapter. The major statistical tests were the t-test for comparing the achievement differences between the control group and experimental group, and the General Linear Model (GLM) for analyzing the variances and covariances.

In this study, the student's background in audio-video electronics, electronic instruments, and computer-aided instruction were treated as control variables (covariates) for those courses closely related to the TV troubleshooting course. Therefore, the analysis of covariance using a GLM was utilized in analyzing the experimental data.

The analysis involved adjusting the sample means of posttest scores by controlling the student's experience so that the posttest scores reflect the expected differences. If the students in different groups had the same average background experience, this procedure could not be necessary. Controlling for experience corresponds to making an adjustment in the observed mean of posttest scores so that the true values reflect what the researcher expected if the two groups of subjects were equal, on the average, in experience.
Since the covariance analysis was used to control test error and increase precision, several assumptions were tested first. After these assumptions were confirmed, the posttest scores of the two groups were adjusted by the covariates and the adjusted means were then statistically compared.

The assumptions necessary for the valid use of covariances are that:

1. The covariances are fixed and independent of treatments.
2. The regression of achievement on covariances after removal of treatment differences are linear and independent of the treatment.
3. The residuals are normally and independently distributed with zero mean and a common variance.

Testing Assumptions for Multiple Covariance Analysis

The following steps were used to satisfy the assumptions underlying the analysis of covariance:

Step one: Testing for the group variances

The first step was to determine if the group variances of two different groups in audio-video electronics, electronic instrument, and computer-aided instructions were statistically equal.

1. Null hypothesis for audio-video electronics scores:

   There were no significant differences in the true group variances of audio-video electronics scores
between the two groups.

Hoa: Aca=Aea

TABLE 4. The analysis of variance of audio-video electronics scores

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>DF</th>
<th>SUM OF SQUARE</th>
<th>MEAN SQUARE</th>
<th>F-value</th>
<th>PR&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>1</td>
<td>64.0000</td>
<td>64.0000</td>
<td>1.42</td>
<td>0.2414</td>
</tr>
<tr>
<td>Error</td>
<td>34</td>
<td>1530.5556</td>
<td>45.0163</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>1594.5556</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As shown in Table 4, the F value is 1.42 and the PR value is 0.2414, which is much greater than 0.05. Therefore, the null hypothesis was not rejected. This means there was no significant difference in the true group variances in audio-video electronics scores between the two groups.

2. Null hypothesis for electronic instrument scores:

There was no significant difference in the true group variances of electronic instrument scores between the two groups.

Hob: Ace=Aee

As shown in Table 5, the F value is 4.91 and the PR value is 0.0339, which is less than 0.05. Therefore, the null hypothesis was rejected. This means there was a significant difference in the true group variances in electronic instrument scores between the two
TABLE 5. The analysis of variance of electronic instrument scores

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Square</th>
<th>Mean Square</th>
<th>F-value</th>
<th>P&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>1</td>
<td>36.0294</td>
<td>36.0294</td>
<td>4.91</td>
<td>0.0339</td>
</tr>
<tr>
<td>Error</td>
<td>32</td>
<td>234.5882</td>
<td>7.3308</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>270.6176</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

groups. Hence, the scores of electronic instrument had to be taken as a covariate in analyzing the posttest scores.

3. Null hypothesis for computer-aided instruction scores:

   There was no significant difference in the true group variances of computer-aided instruction scores between the two groups.

   $H_0: \sigma_1^2 = \sigma_2^2$

TABLE 6. The analysis of variance of CAI scores

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Square</th>
<th>Mean Square</th>
<th>F-value</th>
<th>P&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>1</td>
<td>34.7222</td>
<td>34.7222</td>
<td>3.34</td>
<td>0.0862</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>166.2222</td>
<td>10.3889</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>200.9444</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As shown in Table 6, the $F$ value is 3.34 and the PR value is 0.0862, which is greater than 0.05. Therefore, the null hypothesis was not rejected. This means there was no significant difference in the true group variances in CAI scores between the two groups.

From the above three tests of hypotheses, it was confirmed that the true group variances of the scores of audio-video electronics and computer-aided instruction did not have significant differences. Yet, there was a significant difference in the true group variance in electronic instrument scores between the control group and the experimental group at the 0.05 level of significance.

Step two: Testing for the true group means

The following hypotheses were tested to determine if the true group means for audio-video electronics, electronic instrument, and computer-aided instruction were equal. In other words, this procedure was to test if the two groups had the same mean for the control variables. If there was no significant difference between the two groups in their distribution of the control variables, then the results of this control would be accepted for use in the covariance analysis. Otherwise, rerandomization might be necessary before the experiment could be performed or an adjustment of the regression intercept and slope for posttest scores was needed.

1. Null hypothesis for audio-video electronics scores:

There was no significant difference in the true group means for audio-video electronics scores between the
two groups.

H0: $U_a = U_e$

The results of the t-test are shown in Table 7, where the $T$ value is 1.1924. The $PR$ value is 0.2414, which is much larger than 0.05. Therefore, the null hypothesis was not rejected. This means there was no significant difference in the true group means for audio-video electronics scores of the two groups at the 0.05 significance level.

TABLE 7. T-test for the audio-video electronics scores

| TREATMENT | N | MEAN | STD DEV | STD ERROR | T-VALUE | PR>|T|
|-----------|---|------|---------|-----------|---------|------|
| CON       | 18| 78.72| 7.2339  | 1.7050    | 1.1924  | 0.2414|
| EXP       | 18| 76.05| 6.1402  | 1.4472    |         |       |

For H0: Variances are equal, $F' = 1.39$, $Prob>F' = 0.5063$

2. Null hypothesis for electronic instrument scores:

There was no significant difference in the true group means for electronic instrument scores between the two groups.

H0: $U_ec = U_ee$

The results of the t-test are shown in Table 8, where the $T$ value is -2.2169. The $PR$ value is 0.0339, which is less than 0.05. Therefore, the null hypothesis was rejected. This means there was a
significant difference in the true group means for electronic instrument scores of the two groups at the 0.05 significance level.

TABLE 8. T-test for the electronic instrument scores

<table>
<thead>
<tr>
<th>Variable: Electronic Instrument Scores (EI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TREATMENT</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>CON</td>
</tr>
<tr>
<td>EXP</td>
</tr>
</tbody>
</table>

For H0: Variances are equal, F*=1.58, Prob>F'=0.3723

3. Null hypothesis for CAI scores:
   There was no significant difference of the true group means for CAI scores between the two groups.

H0f: Ucc=Uce
   The results of the t-test are shown in Table 9, where the T value is 1.8282. The PR value is 0.0984, which is greater than 0.05. Therefore, the null hypothesis was not rejected. This means there was no significant difference in the true group means for CAI scores of the two groups at the 0.05 significance level.

From the above three tests of hypotheses, it was confirmed that the true group means of the audio-video electronics scores and CAI scores did not have significant differences between the control group and the experimental group. However, the true group means of
TABLE 9. T-test for the CAI scores

| TREATMENT | N  | MEAN | STD DEV | STD ERROR | T-VALUE | PR>|T| |
|-----------|----|------|---------|-----------|---------|-----|
| CON       | 9  | 90.44| 1.4240  | 0.4746    | 1.8282  | 0.0984 |
| EXP       | 9  | 87.67| 2.9950  | 1.4433    |         |      |

For Ho: Variances are equal, F'=9.25, Prob>F'=0.0050

electronic instrument scores had significant differences at the 0.05 significance level.

Step three: Testing the within groups' regression coefficient

This step was to test the hypothesis stating that the within groups' regression coefficients were equal. The test involved checking for interaction by determining whether the best-fitting straight lines for observations within each group had different slopes. If the evidence failed to reject the null hypothesis of no interaction, then a collection of lines could be expressed with identical slopes.

Null hypothesis: There was no significant difference in the interaction between posttest group means and audio-video electronics, electronic instrument, and CAI scores.

H0g: Bca=Bea=Ba
H0h: Bce=Bee=Be
H0i: Bcc=Bec=Bc
The results of the GLM analysis are shown in Table 10. It is obvious there is no PR>F smaller than 0.05. Therefore, the null hypothesis was not rejected. The two groups statistically had no significant difference in the interaction between posttest group means and audio-video electronics, electronic instrument, and CAI scores.

### TABLE 10. The GLM analysis of the interaction of covariances with group means

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>F-Value</th>
<th>PR&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRT</td>
<td>1</td>
<td>1061.09</td>
<td>2.94</td>
<td>0.1172</td>
</tr>
<tr>
<td>AV</td>
<td>1</td>
<td>252.04</td>
<td>0.70</td>
<td>0.4229</td>
</tr>
<tr>
<td>EI</td>
<td>1</td>
<td>287.22</td>
<td>0.80</td>
<td>0.3933</td>
</tr>
<tr>
<td>CAI</td>
<td>1</td>
<td>91.36</td>
<td>0.25</td>
<td>0.6258</td>
</tr>
<tr>
<td>AV*TRT</td>
<td>1</td>
<td>168.13</td>
<td>0.47</td>
<td>0.5104</td>
</tr>
<tr>
<td>EI*TRT</td>
<td>1</td>
<td>0.83</td>
<td>0.00</td>
<td>0.9627</td>
</tr>
<tr>
<td>CAI*TRT</td>
<td>1</td>
<td>278.48</td>
<td>0.77</td>
<td>0.4004</td>
</tr>
</tbody>
</table>

The pooled GLM analysis of the two groups is shown in Table 11. The F-value is 0.85 and PR>F is 0.5749. This means the null hypothesis can not be rejected. The regression lines between posttest scores and audio-video electronics, electronic instrument, and CAI scores for subjects in control group and experimental group are parallel to each other.

From the above tests of the hypotheses, it was confirmed that the within true groups' regression coefficients were equal. This means the
TABLE 11. The pooled GLM analysis of covariance

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>DF</th>
<th>SUM OF SQUARES</th>
<th>MEAN SQUARE</th>
<th>F-VALUE</th>
<th>PR&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>7</td>
<td>2139.15</td>
<td>305.59</td>
<td>0.85</td>
<td>0.5749</td>
</tr>
<tr>
<td>Error</td>
<td>10</td>
<td>3609.35</td>
<td>360.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>5748.50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

two groups had statistically identical slopes in audio-video electronics, electronic instrument, and CAI scores. Therefore, the two groups had the homogeneity of variance and normality. This was a reasonable background for this experiment.

Results of Hypotheses Testing

Hypothesis 1: There was no significant effect of audio-video electronics scores upon the achievement scores in learning TV troubleshooting knowledge and skills.

Since the interaction of three courses within each group was not significant, the effect of one course to the posttest and skills test could be checked with the GLM test without the effect of treatment. Table 12 shows the results of GLM analysis. It is obvious that both PR>F values are much larger than 0.05, thus, the null hypothesis cannot
be rejected. It means that audio-video electronics instruction did not have a significant effect on the posttest and skills test scores.

TABLE 12. The GLM analysis of posttest and skills test on audio-video electronics instruction

<table>
<thead>
<tr>
<th>DEPENDENT VARIABLE</th>
<th>SOURCE</th>
<th>TYPE I SS</th>
<th>F-VALUE</th>
<th>PR&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSTTEST</td>
<td>AV</td>
<td>244.45</td>
<td>1.07</td>
<td>0.3090</td>
</tr>
<tr>
<td>SKILL TEST</td>
<td>AV</td>
<td>178.49</td>
<td>0.74</td>
<td>0.3969</td>
</tr>
</tbody>
</table>

Hypothesis 2: There was no significant effect of electronic instrument scores upon the achievement scores in learning TV troubleshooting knowledge and skills.

The results of the GLM procedure are summarized in Table 13. The PR value of EI to the posttest is larger than the established 0.05 level of significance, but the PR value of EI to the skills test is smaller than the 0.05 level. Thus, the null hypothesis, if divided into two parts, it cannot be rejected for the first part, but it can be rejected for the second part. Results indicate that the instruction of electronic instrument had a significant effect on the TV skills learning but had no significant effect on TV knowledge learning.

In order to determine the relationship between the EI scores and the skills test scores, the researcher used the Pearson correlation method as a check. The correlation coefficient between these two
TABLE 13. The GLM analysis of posttest and skills test on electronic instrument instruction

<table>
<thead>
<tr>
<th>DEPENDENT VARIABLE</th>
<th>SOURCE</th>
<th>TYPE I SS</th>
<th>F-VALUE</th>
<th>PR&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSTTEST</td>
<td>EI</td>
<td>395.27</td>
<td>1.61</td>
<td>0.2134</td>
</tr>
<tr>
<td>SKILL TEST</td>
<td>EI</td>
<td>1701.15</td>
<td>8.59</td>
<td>0.0063</td>
</tr>
</tbody>
</table>

courses is shown in Table 14 with a positive value of 0.4279 and the PR value for testing the null hypothesis RHO=0 is 0.0116. Therefore, the null hypothesis was rejected. It means the electronic instrument scores were positively correlated with skills test scores. Since the contents of electronic instrument instruction covered many items of operating the instruments that could be used for TV troubleshooting, this finding is a reasonable result.

TABLE 14. Pearson correlation coefficient of the EI score and the skills test score

<table>
<thead>
<tr>
<th>Prob&gt; R under Ho:Rho=0/N=36</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
</tr>
<tr>
<td>EI</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SKILLS TEST</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Hypothesis 3: There was no significant effect of CAI scores upon the achievement scores in
learning TV troubleshooting knowledge and skills.

The results of the GLM test for CAI to posttest and skills test are shown in Table 15. Both PR values are larger than the 0.05 level of significance. Thus, the null hypothesis cannot be rejected. Therefore, there was no significant effect of CAI instruction upon the achievement scores in learning TV troubleshooting knowledge and skills. But CAI instruction had more effect on the skills test than the knowledge posttest results.

TABLE 15. The GLM analysis of posttest and skills test on CAI instruction

<table>
<thead>
<tr>
<th>DEPENDENT VARIABLE</th>
<th>SOURCE</th>
<th>TYPE I SS</th>
<th>F-VALUE</th>
<th>PR&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSTTEST</td>
<td>CAI</td>
<td>134.66</td>
<td>0.42</td>
<td>0.5279</td>
</tr>
<tr>
<td>SKILL TEST</td>
<td>CAI</td>
<td>586.36</td>
<td>2.11</td>
<td>0.1671</td>
</tr>
</tbody>
</table>

Hypothesis 4: There was no significant achievement difference between the two groups of students who studied TV troubleshooting knowledge by the traditional method versus the DVI method.

For this hypothesis, the EI scores did not have a significant effect on the posttest scores (knowledge test scores). Hence, the reduced model did not work here. The suitable statistical method is
the t-test with the variable 'DIFF', where DIFF is the score difference between pretest and posttest of each person in the two groups. From Table 16, the means for the control group is 17.00, yet the means of the experimental group is 27.89. It means the two groups both improved their TV troubleshooting knowledge after instruction, but the experimental group made a larger improvement than the control group.

The T-value is -2.2552 and the PR>|T| is 0.0307, which is smaller than the 0.05 significance level. Therefore, the null hypothesis was rejected for the significance level of 0.05. It means the DVI method had more effect than the traditional method on learning TV troubleshooting knowledge in this study.

TABLE 16. The analysis of the achievement difference between the control group and the experiment group

| TREATMENT | N  | MEAN | STD DEV | STD ERR | T     | PR>|T| |
|-----------|----|------|---------|---------|-------|------|
| CON       | 18 | 17.00| 14.84   | 3.49    | -2.2552| 0.0307|
| EXP       | 18 | 27.89| 14.13   | 3.33    |        |       |

For Ho: Variable are equal, F'=1.10, Prob>F'=0.8418

Hypothesis 5: There was no significant achievement difference between the two groups of students who studied TV troubleshooting skills by the traditional method versus the DVI method.
The total skills test included precisely troubleshooting a defective TV set within 50 minutes [note: the 50 minutes is the maximum time for troubleshooting three frequently defective parts in the vocational training standard in Taiwan]. It involved making correct judgments and using proper instruments to deal with the defective parts within the time limit. The test contained the testing of the circuits of horizontal deflection, vertical deflection, and chromatic processing circuits. The score was calculated by the rules of the National TV Technician Standard Test in Taiwan, which calculated the precision score with 80% and the speed score with 20% of the total score. The equation used for calculating the total skills test score was:

$$TSKL = \frac{(\text{Precision Score}/3) \times 0.8 + \text{Time Score} \times 0.2}{3}$$

The EI scores had a significant effect on the total skills test scores as reported earlier in the testing of Hypothesis 2. The reduced model tested this hypothesis in which the EI score was taken as a covariate. The results of the GLM procedure are shown in Table 17. It is obvious that the F-value of the treatment is 7.31 and the PR>F value is 0.0110. Since 0.0110 is smaller than the established 0.05 significance level, the null hypothesis was rejected at the 0.05 significance level. This means that the effect of treatment was significant. In other words, the skills test scores of the experimental group were significantly different from that of the control group.

Hypothesis 6: There was no significant time consumption difference between the two groups of students
TABLE 17. The analysis of the skills test difference between the control group and the experimental group

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>DF</th>
<th>TYPE I SS</th>
<th>F-VALUE</th>
<th>PR&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>EI</td>
<td>1</td>
<td>1701.15</td>
<td>8.59</td>
<td>0.0063**</td>
</tr>
<tr>
<td>TRT</td>
<td>1</td>
<td>1447.94</td>
<td>7.31</td>
<td>0.0110*</td>
</tr>
<tr>
<td>ERROR</td>
<td>31</td>
<td>6138.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>33</td>
<td>9287.17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Control group mean: 60.51
Experimental group mean: 77.82
Duncan's critical range: 9.8388
Means are significantly different

*Significant at the 0.05 level.
**Significant at the 0.01 level.

for dealing with the same defective circuits, one group using the traditional method, while the other group using the DVI method.

The time consumption for dealing with the same defective circuits were counted with a timer and recorded by the judges. According to the records, the maximum time spent was 48 minutes and the minimum time spent was 24 minutes for three questions. The judges did not accept the student's hand-in unless they finished the three questions.

The results of the GLM test for the time consumption are shown in Table 18. The F-value is 18.34 and the PR>F is 0.0001. This is an extremely significant level. Hence, the null hypothesis was rejected. Therefore, there was a significant time consumption difference between
the control group and the experimental group. It means the DVI method enabled students to work faster in carrying out TV troubleshooting procedures than the traditional method.

TABLE 18. The analysis of time consumption between the control group and the experimental group

<table>
<thead>
<tr>
<th>Dependent Variable: Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SOURCE</strong></td>
</tr>
<tr>
<td>TRT</td>
</tr>
<tr>
<td>ERROR</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

Time mean: 35.11
Control group mean: 39.00
Experimental group mean: 31.22
Duncan's critical range: 3.6894
Means are significantly different

***Significant at the 0.001 level.

Since the time consumption is based on the tools one has used and on previous experiences, the senior students might work faster than the junior students. Table 19 shows the time consumption differences between the different grades and different treatment groups. It shows that no sufficient significant differences between the two grades existed. The PR>F value is 0.2196 which is larger than 0.05. Therefore, the time used in TV troubleshooting was not significantly different between the junior and senior groups. It is clear that the
The junior experiment group spent the shortest time (27.00') and the junior control group spent the longest time (41.44'). The grade difference did not have a significant effect on time consumption for TV troubleshooting. But, the treatment difference had a significant effect on it.

<table>
<thead>
<tr>
<th>Dependent Variable: Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOURCE</td>
</tr>
<tr>
<td>TRT</td>
</tr>
<tr>
<td>GRADE</td>
</tr>
<tr>
<td>GRADE*TRT</td>
</tr>
<tr>
<td>ERROR</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

Time mean: 35.11'
Junior control group mean: 41.44'
Senior control group mean: 36.55'
Junior experimental group mean: 27.00'
Senior experimental group mean: 35.44'
Junior mean: 34.22'
Senior mean: 36.00'

Hypothesis 7: There was no significant achievement differences between junior and senior students in a university in learning TV troubleshooting knowledge and skills.

***Significant at the 0.001 level.
It is possible to test whether TV troubleshooting instruction courseware is better taught to juniors or seniors in NTNU. The basic difference between these two grades, in the Department of Industrial Education, National Taiwan Normal University, is that senior students had studied a CAI course and the junior students had not. It is the required course offered to senior students.

If the achievement differences between these two grades were not significant, the recommendation might be made to the department office to decide the suitable time for offering TV troubleshooting courseware. From Table 20, the PR>F values of both posttest (knowledge) and skills test are greater than 0.05. So, the null hypothesis can not be rejected. This means TV troubleshooting courseware can be taught in either the senior year or junior year at NTNU.

For further understanding about the suitable time for this course to be offered, the knowledge achievement scores and skill achievement scores are listed in Table 20. It is obvious that the students in the junior step made a larger achievement gain than in the senior group.

Hypothesis 8: There was no significant preference among the students of experimental group in applying image database for TV troubleshooting instruction.

A simple questionnaire was answered by the experimental group at the end of the experiment. Its purpose was to understand the students' attitudes to this new TV troubleshooting instruction method and how many deficiencies needed to be improved for future use.
TABLE 20. The analysis of the achievement difference between two grades in learning TV troubleshooting knowledge and skills

<table>
<thead>
<tr>
<th>DEPENDENT VARIABLE</th>
<th>SOURCE</th>
<th>TYPE I SS</th>
<th>F-VALUE</th>
<th>PR&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSTTEST</td>
<td>GRADE</td>
<td>529.00</td>
<td>2.14</td>
<td>0.1524</td>
</tr>
<tr>
<td>SKILL TEST</td>
<td>GRADE</td>
<td>63.11</td>
<td>0.22</td>
<td>0.6433</td>
</tr>
</tbody>
</table>

Mean of posttest for junior group: 68.17
Mean of posttest for senior group: 60.50
Duncan's critical range for posttest: 10.64
Mean of skill test for junior group: 70.57
Mean of skill test for senior group: 67.93
Duncan's critical range for skill test: 11.51

The questionnaire was developed by this researcher and included five simple questions using the Likert scale. The lowest category was assigned to 1, the next category a 2, etc., up to the highest category which was assigned as 5. The lowest category means strongly disagree, the next one means disagree, then neutral, agree, and finally, strongly agree. Every question was designed to test the fitness of student's attitudes about the DVI courseware application. The questions are listed as follows:

1. It is feasible to edit teaching materials with the image processing technique.

2. It is profitable to learn TV troubleshooting with an expert-system-based courseware.

3. The effect of image processing in instruction is better than text.
4. The image-processing-based courseware is more useful than conventional CAI courseware.

5. The expert-system-based learning style can save much time for learning complicated technical courses.

The SAS program PROC FREQ was used to test the subject's selection for each question. Table 21 shows the percentage of each category among the 18 samples. It is obvious that the student's attitude tended to prefer DVI instruction method. For question one, 94.44% agreed; for question two, 88.89% agreed; for question three, 93.34% agreed; for question four, 77.78% agreed; and for question five, 83.33% agreed.

TABLE 21. The frequency distribution of the attitude about the TV troubleshooting courseware

<table>
<thead>
<tr>
<th>ATTITUDE</th>
<th>QUEST1</th>
<th>QUEST2</th>
<th>QUEST3</th>
<th>QUEST4</th>
<th>QUEST5</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRONGLY DISAGREE</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>DISAGREE</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>5.56%</td>
<td>5.56%</td>
<td>0%</td>
<td>5.56%</td>
</tr>
<tr>
<td>NEUTRAL</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>5.56%</td>
<td>5.56%</td>
<td>11.11%</td>
<td>22.22%</td>
<td>11.11%</td>
</tr>
<tr>
<td>AGREE</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>44.44%</td>
<td>22.22%</td>
<td>27.78%</td>
<td>27.78%</td>
<td>44.44%</td>
</tr>
<tr>
<td>STRONGLY AGREE</td>
<td>9</td>
<td>12</td>
<td>10</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>50.00%</td>
<td>66.67%</td>
<td>55.56%</td>
<td>50.00%</td>
<td>38.89%</td>
</tr>
</tbody>
</table>
The GLM test for the total answers variance between each pair of questions are shown in Table 22. It is clear that the F-value is 0.47 and PR>F is 0.7563, which is much larger than the 0.05 significance level. Therefore, there were no significant answer differences between each pair of questions. It means the answers of each student did not have a significant difference. The means of every question are larger than the 4.0 agree scale point. And the total mean is 4.3445. Therefore, students tend to prefer DVI courseware.

TABLE 22. The analysis for the differences of the answers among all questions

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>DF</th>
<th>TYPE I SS</th>
<th>MEAN SQUARE</th>
<th>F-VALUE</th>
<th>PR&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUEST</td>
<td>4</td>
<td>1.2667</td>
<td>0.3167</td>
<td>0.47</td>
<td>0.7563</td>
</tr>
<tr>
<td>ERROR</td>
<td>85</td>
<td>57.0556</td>
<td>0.6712</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>89</td>
<td>58.3223</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean of question 1: 4.4444
Mean of question 2: 4.5000
Mean of question 3: 4.3333
Mean of question 4: 4.2777
Mean of question 5: 4.1667
Total mean: 4.3445

In order to understand the student's attitudes in greater detail, PROC MEANS in the SAS package was used to test the condition of preference. It compared the largest probability to the smallest probability for each question, and calculated the T-value for each
comparison. Table 23 shows the results of the test for each question. It is obvious that every PR>T value is smaller than the 0.05 alpha value. Therefore, the null hypothesis was rejected. From results reported in Tables 21, 22, and 23, it can be concluded that there was a significant preference among students for applying the image processing technique to learning TV troubleshooting.

**TABLE 23. The analysis of the preference variances for each question**

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>MEAN</th>
<th>STD DEV</th>
<th>STD ERR</th>
<th>T</th>
<th>PR&gt;T</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUEST 1</td>
<td>4.4444</td>
<td>0.6157</td>
<td>0.1451</td>
<td>30.63</td>
<td>0.0001***</td>
</tr>
<tr>
<td>QUEST 2</td>
<td>4.5000</td>
<td>0.8575</td>
<td>0.2021</td>
<td>22.26</td>
<td>0.0001***</td>
</tr>
<tr>
<td>QUEST 3</td>
<td>4.3333</td>
<td>0.9075</td>
<td>0.2139</td>
<td>20.26</td>
<td>0.0001***</td>
</tr>
<tr>
<td>QUEST 4</td>
<td>4.2778</td>
<td>0.8264</td>
<td>0.1948</td>
<td>21.96</td>
<td>0.0001***</td>
</tr>
<tr>
<td>QUEST 5</td>
<td>4.1667</td>
<td>0.8575</td>
<td>0.2021</td>
<td>20.62</td>
<td>0.0001***</td>
</tr>
</tbody>
</table>

***Significant at the 0.001 level.

**Findings from the Courseware Development**

After the application of an image database to the development of an expert-system-based DVI courseware for TV troubleshooting instruction, the following results were confirmed through the experiences.

1. It is possible to simplify a complicated technical instruction procedure if the key to the logic rules of the system can be found. The key of the TV troubleshooting instruction is to recognize the
symptoms with four factors: raster, picture, color, and sound. Any defective symptom can be combined with these four factors. Using these factors to classify the symptoms can make the troubleshooting procedure simpler.

2. The knowledge of multiple experts can be made available to work simultaneously and continuously on a problem at any time. Today's microcomputer hardware and software make the expert system last indefinitely. The knowledge organized by several experts is wider than from only one expert. The level of expertise combined from several experts may exceed that of a single human expert.

3. An expert system may respond faster and be more available than a human expert. For an interactive courseware, fast response is necessary. It is feasible to save much learning time if the system is designed in a reasonable sequence.

4. The knowledge is explicitly known in the expert system instead of being implicit in the expert's mind. It can be examined for correctness, consistency, and completeness.

5. The quality of an image-based courseware depends largely on the resolution of the image frame grabber and the display resolution. If these two resolutions are different, the image will be blurred and cause a negative effect. Besides, in order to have a clear view of the picture on the monitor, the size of the characters should be big enough. Hence, the number of the label characters should be reduced to a small limit that may make the sentence incomplete or too simple to
make sense. The Chinese character has this display difficulty on the monitor screen with more words at one time.

6. The PC Album software can accept any signal from VCR, the video camera, and the laser disk. It is possible to create a courseware from multiple signal sources. The editing of the courseware with an image database is faster than other CAI methods. But, the author must organize the system logic before he/she starts to work.
CHAPTER VI. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The researcher summarizes the results of the previous chapters and draws conclusions from the research findings in this chapter. Several recommendations for further studies are proposed.

Summary

Research background

The technology of education is advancing with the development of industrial technology. Their interaction has made human civilization a marvelous period. The more high technology production applications in education are utilized, the more high quality human resources can be produced. If educators want to prepare young people for a career in modern industry, they must take the main stream of industry into account, and that is "computerization."

Digital image processing is one of the most prospective fields in computer engineering. It has been used for remote sensing, medical diagnosis, meteorology, and many other fields. After more than thirty years of development, this technology is coming into a rapid expansion era. It is time to apply this technology to education. For the TV industry, the use of high technology for TV troubleshooting is no exception.
Since the TV troubleshooting instruction includes displaying many diagnostic pictures for trouble recognition, the application of digital image processing technology for this instruction may be helpful and effective for simplifying complicated teaching procedures. It is hoped that the courseware designed with an image database and in an interactive mode may help students learn TV troubleshooting with less difficulty. If this new teaching method proves to be more effective than the traditional TV troubleshooting instruction method, the courseware may be modified and applied to general teaching activities.

Traditional TV troubleshooting instruction, including classroom lecture and laboratory training, plays a useful role, but it is often inadequate for teaching complex diagnostic and repair skills. The learners always repeat the same procedures for dealing with the existing troubles in the different types of TV sets until they are able to combine knowledge with actual experience. It is a time-consuming and less-effective experience for them to apply the knowledge in real troubleshooting work. Moreover, the teachers must spend a lot of time renewing their teaching material in order to meet the proliferation of TV circuits, especially for preparing a lot of pictures for teaching diagnosis.

Research design

A computer-based instruction courseware was designed for this study as a prototype to offer more instructional flexibility and
trainee interaction than traditional methods. It mainly consisted of a TV troubleshooting expert system (software), and a digital image processing card (hardware) installed in a 386' IBM PC/AT microcomputer. The images were grabbed by a video camera and processed with image processing packages within a microcomputer.

The expert system developed for this study provided a knowledge base which followed the rules of "proceduralized problem-solving" and consisted of a knowledge base, an image base, and an inference engine. The knowledge base included a library of decision-making rules, frames of troubleshooting procedures, and frames of learning units. The image base contained test patterns, block diagrams, stage circuits, and symptomatic pictures. The inference engine included a frame and rule interpreter, user commands, and a screen interface. Since the PC Album database was taken as the backbone program, some of the user commands and screen interface were adopted from that package. One can easily modify the data, picture, and data structure as the needs arises.

The decision-making rules were organized with 'IF-AND-THEN-OR' logic. Every trouble condition was encoded in alphanumeric code, and the symptoms were encoded in the same way. Also, every image was assigned a filename which could be easily retrieved. If the answer is an image, the inference engine will load the image to the screen.

The hardware system consists of an IBM PC/AT (80386-25MHz), a frame grabber (CFG-512N), a NTSC CCD VTR camera, and a multisync color monitor (NEC 2A). The total cost of this system was US$6,600.
Because of the limited financial conditions and the limited computer memory capacity, the learning units included in this experiment contained only the following items:

1. functions of color TV block circuits,
2. functions of adjustment controls,
3. functions of test patterns,
4. major defective images,
5. vertical sweep section circuit,
6. horizontal sweep section circuit, and
7. chroma sweep section circuit.

Most learning units were edited in English and organized with simple sentences. It is less of a problem for the junior and senior undergraduate students at the National Taiwan Normal University to read the courseware written in English. In addition to this, the complicated structure of the Chinese character makes the display screen hard to contain sufficient words in a page on the computer screen.

The courseware was then taken as a prototype of computer-based TV troubleshooting instruction teaching material to test for its effectiveness with the junior and senior students at the National Taiwan Normal University. Eighteen students were selected from each grade and randomly assigned to one of the two groups. One was the control group, which was treated with traditional teaching method; the other was the experimental group which was treated with computer-based courseware (or called DVI courseware). Both groups studied the same
learning units within one month. In order to reduce the Hawthorne Effect and the John Henry Effect, these two groups were arranged to study at different classrooms and taught by different instructors.

In the beginning of the experiment, they were given a pretest to determine the knowledge about TV troubleshooting. At the end of the experiment, a posttest and a skills test were given to subjects to check their achievement of the learning activity. The items for these two tests were selected from the NHK TV Electrician Standard Test which was a norm test for vocational training in Taiwan. The selected items were divided into three different parts, each with different item difficulties. The number of test items were similar and were selected from high, middle, and low difficulty item sets. Therefore, the difficulties of these two tests were logically the same.

Since the student's former experiences may have some effects on the posttest and skills test, the covariance analysis was used to control the test error and increase precision. There were three courses closely related to the TV troubleshooting and were considered as statistical covariates. They were audio-video electronics, electronic instruments, and computer-aided instruction, which were required courses offered from the Industrial Education Department in National Taiwan Normal University. Both junior and senior students already studied the former two courses, but only senior students studied computer-aided instruction. This situation was controlled to determine the achievement differences between these two grades, one group with CAI experience and the other group without CAI experience.
The SAS package was used for analyzing the experimental results. The t-test was used for testing the achievement differences between the control group and the experimental group. The GLM test was used for analyzing the variances and covariances of the other comparisons. All significance tests were checked at the 0.05 alpha level for human bias.

The covariances test should be more accurate if the assumptions of group variances, true group means, and within groups' regression coefficient of the three covariate courses were tested first to confirm the homogeneity of random sampling. After confirmation of the above assumptions, the underlying analysis of covariance were determined.

Research results

No significant differences existed in the true group variances in the courses of audio-video electronics and computer-aided instruction. Yet, the difference was significant in the true group variance in electronic instrument scores between the control group and the experimental group. The same situation existed for the case of testing true group means. The slopes for the scores of the three courses were statistically identical after testing their regression coefficients. Therefore, the two groups had the homogeneity of variance and normality with respect to their earned scores in the three courses.

For the tests of the eight hypotheses, the results are summarized as follows:

1. Hypothesis 1: The PR>F value for the posttest is 0.3090, and for
the skills test is 0.3969. The null hypothesis was not rejected. Therefore, the audio-video electronics did not have a significant effect on knowledge achievement, nor on the skills test.

2. Hypothesis 2: The PR>F value of the electronic instrument scores to the posttest scores is 0.2134, but the skills test is 0.0063. Therefore, the instruction of electronic instrument had a significant effect on TV skills learning, but had no significant effect on TV knowledge learning. The Pearson correlation coefficient of the EI score and skills test was 0.4279. Therefore, the second part of this hypothesis, namely the skill component was rejected.

3. Hypothesis 3: The PR>F value of the CAI score on the posttest score was 0.5279 and to the skills test it was 0.1671. Both are larger than the 0.05 alpha level of significance. The null hypothesis was not rejected. Therefore, the CAI instruction had no significant effect on TV troubleshooting knowledge and skills learning.

4. Hypothesis 4: The PR>T value of the achievement difference between the control group and the experimental group was 0.0307. The null hypothesis was rejected
at the 0.05 significance level. Thus, the DVI instruction method yielded higher student achievement scores than did the traditional instruction method. Therefore the DVI method was more effective than the traditional method on learning TV troubleshooting knowledge.

5. Hypothesis 5: The PR>F value was 0.0110, after eliminating the effect of the covariate (EI). The null hypothesis was rejected. This means the effect of treatment was significant. Therefore, the mean of the skills test of the experimental group was much higher than the mean of the control group.

6. Hypothesis 6: The PR>F value was 0.0001 for analyzing the time consumption between the control group and the experimental group in the skills test. The null hypothesis was rejected. Therefore, there was a significant time consumption difference between these two groups for dealing with the same defective circuits. The control group mean was 39.00 minutes, whereas the experimental group mean was 31.22 minutes, which was significantly less than the control group.

7. Hypothesis 7: The PR>F value for the knowledge achievement differences between junior and senior students
was 0.1524 and for skills achievement it was 0.6433. Both are larger than 0.05 significance level. Therefore, the null hypothesis was not rejected. It means senior students did not make greater achievement than the junior students in learning TV troubleshooting knowledge and skills. The posttest average score of senior group was 60.50, whereas the junior group was 68.17. The skills test average score of senior group was 67.93 and the junior group was 70.57. The posttest date and skills test date were closed to the graduation date for the senior students and may have caused them not to concentrate their attention to the research project tests. In addition to this, the junior students were more curious about the DVI courseware that made them study harder than senior students. Thus, the junior students got higher scores on the posttest and the skills test than the seniors.

8. Hypothesis 8: The PR>T value was .0001 for analyzing the preference variance for DVI courseware among the students of the experimental group. The null hypothesis was rejected. Thus, this means that most students selected the same answer for one question listed in the questionnaire. Therefore,
it can be concluded that there was a significant preference for DVI courseware among all experimental group students. The total mean of five questions was 4.3445 on the Likert 5-point scale.

Research findings

After the expert system was developed and practically applied to TV troubleshooting instruction, it was found that the simplification of a complicated technical instruction, such as teaching TV troubleshooting, was feasible and workable for technical teachers. The key to building this expert system was to find the control rules by analyzing the symptoms of the color TV set. Once the rules were established, the structure of the knowledge base was built. The rules used to classify the TV symptoms in this study included the four essential factors: raster, picture, color, and sound. Any TV symptom can be composed of any combination of these four factors.

The image database included more information than the traditional CAI courseware. Any signal that comes from VCR, video camera, and laser disk can be input into a frame grabber interface and processed by the microcomputer. The real time image can be stillled for modification and saved to the hard disk for further use. The availability of the image processing technique has made editing easier and faster.

The quality of an image-based courseware depends largely on the resolution of the image frame grabber and the color monitor. Both must be matched, or the image may be blurred and cause the negative effect.
The proliferation of TV production has made TV troubleshooting complicated. Different types of TV sets have different circuits. But, the principles for TV troubleshooting are practically the same. If students understand the principles first and then go into more details for solving the problem for a specific TV set, more time will be saved than learning by traditional approaches.

A knowledge-based expert system may serve more information than human experts. The level of expertise combined from several experts may exceed that of a single expert. A perfect expert system must be modified and updated by multiple experts.

The student's knowledge backgrounds did not have a significant effect on learning TV troubleshooting knowledge. But, the skills backgrounds had a significant effect on learning TV troubleshooting skills through DVI courseware. This means the achievement of knowledge for a specific technical topic can be quickly reached within a short time, if the knowledge was organized with an acceptable model. But, the dexterity of operating instruments can not be reached within a short time. It is by nature that the hands are always slower than the brain and the brain instructs the hands to operate efficiently.

The main effectiveness of this DVI courseware was to aid the students in making a correct decision within a short time when they confront a trouble situation. Thus, much time can be saved for learning TV troubleshooting.
Conclusions

Some problems stated in Chapter 1 were solved as a consequence of this study. First, the difficulty of clearly displaying the troubleshooting procedure was solved by a developed knowledge-based expert system in which a subprogram called 'Troubleshooting Procedure' was designed to arrange the troubleshooting procedure in a logical sequence for general TV circuits and to display it on the color monitor. After consulting experts in the TV industry, the logical sequences for the troubleshooting procedure were listed according to the probability of the failure rate and coded as a part of the knowledge base.

Second, the difficulty of correctly classifying the reasons for troubles was solved by the developed decision-making rules which were designed with IF-THEN logic and then classifying the reasons for TV troubles into four factors: raster, picture, color, and sound. It was also coded as a subprogram of knowledge base and used with the experimental group.

The third problem concerned the difficulty of diagnosing a malfunction at the right place quickly. This problem uses both knowledge and skills to solve. To test the knowledge gained, a posttest was given to the students to check their decision-making abilities. To determine skills, a skills test was given to both groups to compare skills achievement difference between them at the completion of the experiment. The SAS package was applied to analyze the
achievement differences. The results of the statistical analysis are summarized as follows:

1. There was no significant effect of audio-video electronics instruction upon the achievement scores in learning TV troubleshooting knowledge and skills (Hypothesis 1).

2. There was no significant effect of electronic instrument instruction upon the achievement scores in learning TV troubleshooting knowledge, but the instruction of the electronic instrument had a significant effect on the TV skills learning (Hypothesis 2).

3. There was no significant effect of CAI instruction upon the achievement scores in learning TV troubleshooting knowledge and skills (Hypothesis 3).

4. There was a significant achievement difference between the two groups of students who studied TV troubleshooting knowledge by the traditional method versus the DVI method (Hypothesis 4).

5. There was a significant achievement difference between the two groups of students who studied TV troubleshooting skills by the traditional method versus the DVI method (Hypothesis 5).
6. There was a significant time consumption difference between the two groups of students for dealing with the same defective circuits, one group used the traditional method, while the other group used the DVI method (Hypothesis 6).

7. There was no significant achievement difference between the students of the senior grade and the junior grade in learning TV troubleshooting knowledge and skills (Hypothesis 7).

8. There was a significant preference among the experimental group students for applying image database in TV troubleshooting instruction (Hypothesis 8).

It is clear that the audio-video electronics, CAI, and electronic instrument courses had no significant effect on learning TV troubleshooting knowledge. But, electronic instruments had a significant effect on learning TV troubleshooting skills. The reason may be the contents of these two courses were closely related. Especially the fact that both courses used similar instruments to deal with the symptoms of the electronic circuits may have produced or contributed to the significant results.
The statistical analysis results for Hypotheses 4 to 6 showed the experimental treatment as having an effect on the experimental factors. The two groups had significant achievement differences in learning TV troubleshooting knowledge and skills. The time consumption difference had a significant difference. This means the DVI courseware made TV troubleshooting instruction more efficient than the traditional method.

The results of this study also implied that the lack of CAI experience did not cause any negative influence on learning the DVI courseware. On the contrary, the students who did not have any former experience on CAI made a greater significant achievement than the students who already had CAI experience. The reason may be curiosity or the quality of the courseware.

From the standpoint of a technical teacher, to simplify the teaching material preparation procedure with an expert system may be a good policy. Since the knowledge base contained in an expert system was the merit accumulation of multiple experts and was organized in a logical sequence, it would be very profitable to teach a technical course aided by such a software system.

In addition to a suitable software, sufficient hardware is also needed to make the courseware system complete. The function of the image processing board may decide the model of images displayed on the monitor. For editing the courseware, the VCR camera and the image frame grabber must have the same resolution or the sharpness of the picture may not be good. However, to edit a perfect courseware one
needs sufficient hardware, software, and effective instructional strategies.

Recommendations

According to the research results and findings, the following recommendations are suggested:

1. Once the image frame grabber can output a NTSC composite signal to the TV and receive the real time signal from the TV through the camera, the TV troubleshooting technique may be simpler than that used in this study. It is hoped that the defective image can be directly checked with the symptom image base and show the possible defective parts at once. This further research may be worthy.

2. The editing system for developing an image base courseware is inevitable in the near future. A variety of desk top editors have been developed for commercial use. If an image editor can be operated with simple commands, it would be more profitable for more users.

3. The new TV circuits have been improved and consist of several VLSI chips. Their functions are increasing and are more flexible for receiving NTSC, PAL, and SECAM signals. Furthermore, some of them are equipped with a
self-test chip. Thus, it becomes easier to do TV troubleshooting training with the assistance of a microcomputer. Once the TV set can be directly linked to the computer, the troubleshooting procedure can be better modified and rearranged. Then, the students do not need to spend much time in operating instruments step by step. The major goal they need is to learn how to make decisions for a given trouble.

4. Since the CAI experience had no significant effect on learning DVI courseware, the DVI courseware can be taught earlier than the senior grade. The department office may want to adjust their course schedule based upon the results of this research. To improve the efficiency of the teaching activity, the study for analyzing the interaction between other courses is necessary. To save time and money for learning activities, it is beneficial to both students and faculty members.

5. A further study for designing a centralized computer network to teach technical courses with a control station for the teacher and several user terminals for students is necessary. It may improve the interactive effect between teacher and students. The one-to-one man machine system may not be a good system for learning technical courses. A human teacher can do some things for the students that
an expert system cannot, such as answering student's questions to his/her special situation. Humans are more flexible for dealing with contingent situations or emergencies. A centralized two-way teaching system may combine the benefits for teaching technical courses.

6. This same study may be done for vocational training classes to see the effectiveness of this courseware for TV technician training. But, the courseware must be modified for the different subjects.

7. This same study may be conducted in the beginning of a semester to see the effectiveness of this courseware versus the results of this research.
BIBLIOGRAPHY


ACKNOWLEDGEMENT

In conducting this study, a number of people have made very helpful contributions and suggestions. I express my deepest gratitude to the Ministry of Education of Taiwan. Without financial support from the Ministry, this project would not have been possible.

I would like to express my gratitude to my major professor, Dr. William D. Wolansky, for his kindly assistance and encouragement during the pursuit of graduate study here at Iowa State University. I also wish to express my sincere appreciation to my committee members, Dr. John N. Riley, Dr. Donald J. Mckay, Dr. David J. Carlson, and Dr. Shu-Min Huang, who provided their insight and valuable guidance.

I am also grateful to Dr. Dar-Chin Rau, the Chairman of my department in Taiwan, for his permission to allow me to do the experiment there. Special thanks to Dr. Shih and Prof. Dai and their students who took the television troubleshooting course and spent much time in the experiment. Thanks to Mr. San-Wei Won who helped me debug the expert system. Thanks also to Mr. Hon-Jen Young and many good friends on ISU campus who gave me a helpful brain storm for refining my program.

Finally, I want to pay my endless gratitude and love to my wife, Rebecca, and my daughters, Yung-En and Yung-Ai, who always pray for me to complete this study by the expected date.
## APPENDIX A: THE ROUGH SCORES OF THE SUBJECTS

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Where TSKL = (SKL/3) * 0.8 + TSCORE

TSCORE: 0 (TIME=50') < TIME SCORE (SPEED SCORE) < 20 (TIME=30')
Please check the following personal information with X mark before you answer the instructional questions:

Have you ever learned:

"Audio-Video Technique" ? Yes:__ No:__
"Television Theory" ? Yes:__ No:__
"Computer-Assisted Instruction" ? Yes:__ No:__
"Electronic Instruments" ? Yes:__ No:__

Please answer the following questions within 30 minutes.
Part I: Find the most probable causes or the troubleshooting methods for the following trouble conditions.

1. No picture, no color but raster is O.K.:
   A. B+ low power supply circuit
   B. Tuner circuit
   C. Video intermediate frequency circuit
   D. AGC circuit

2. No sound, but picture, color, and raster are O.K.:
   A. CRT circuit
   B. Picture amplifier circuit
   C. Vertical oscillator
3. Weak picture, but all others are O.K.:
   A. Picture amplifier
   B. Color circuit
   C. AGC circuit
   D. Video intermediate frequency circuit

4. Only one horizontal line:
   A. Horizontal oscillator
   B. Vertical oscillator
   C. Sync separator
   D. Focus circuit

5. No color, but all others are O.K.:
   A. Bandpass filter amplifier
   B. Delayline
   C. Color killer
   D. Video intermediate frequency circuit

6. No red color, but all others are O.K.:
   A. ACC circuit
   B. R-Y circuit
   C. B-Y circuit
   D. G-Y circuit

7. No green, but all others are O.K.:
   A. Color burst circuit
B. R-Y circuit
C. B-Y circuit
D. G-Y circuit

8. No raster, no picture, and no sound:
   A. Low power circuit
   B. High voltage circuit
   C. CRT circuit
   D. Horizontal oscillator

9. Only sound but no raster, no color, and no picture:
   A. Video intermediate frequency circuit
   B. Picture amplifier
   C. High voltage circuit
   D. Low voltage power circuit

10. Bold stripe lines:
    A. CRT circuit
    B. Horizontal oscillator
    C. Vertical oscillator
    D. Tuner

11. Confetti (colored snow):
    A. Tuner
    B. Bandpass filter amplifier
    C. Color killer
    D. ACC circuit
12. Loss of color sync:
   A. Color phase detector
   B. Color killer
   C. Bandpass filter
   D. Color demodulator

13. Loss of focus at the corner of CRT raster:
   A. Static convergent adjustment
   B. Dynamic convergent adjustment
   C. Focus circuit
   D. Electronic guns circuit

14. Dismatch of the color and picture:
   A. ACC circuit
   B. Horizontal sync circuit
   C. 3.58 MHz oscillator
   D. Color demodulator

15. Excessive red color:
   A. Bandpass filter amplifier
   B. B-Y circuit
   C. G-Y circuit
   D. R-Y circuit

16. Loss of picture sync, but sound and color are O.K.:
   A. Sync separator
   B. Horizontal oscillator
17. Negative picture;
   A. Contrast control
   B. AGC circuit
   C. Tuner
   D. Video intermediate frequency circuit

18. Ripple ringing at the edge of the picture:
   A. Delayline
   B. Vertical oscillator
   C. B+ power supply
   D. Horizontal oscillator

19. Pincushion distortion:
   A. Focus circuit
   B. Deflection yoke
   C. Vertical linearity adjustment
   D. Horizontal linearity adjustment

20. Ghost image:
   A. Sync amplifier
   B. AGC circuit
   C. Antenna direction adjustment
   D. Tuner
Part II. Describe the functions of the following parts of the diagnosis image pattern.

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 
Please answer the following questions within 30 minutes.

Part I: Find the most probable causes or the troubleshooting methods for the following trouble conditions.

1. Weak picture, no color but raster is O.K. What adjustment should be done first for helping the diagnosis:
   A. Brightness control
   B. Contrast control
   C. Horizontal hold
   D. Color killer control

2. Retrace line appears when the TV tunes in no-broadcasting channels. The most possible defective part is:
   A. Fine tuning circuit
   B. Blanking circuit
   C. High voltage circuit
   D. Horizontal deflection circuit

3. The picture is scrolling from top to down. What causes it?
   A. Vertical yoke not available
   B. Vertical linearity adjustment no good
   C. Loss of vertical sync
   D. Less gain of sync amplifier
4. Sometimes only one horizontal line, sometimes normal. Why?
   A. A resistor's resistance increase
   B. A capacitor leaks
   C. A transistor overage
   D. Unstable power supply

5. What makes the picture elongate in the vertical direction?
   A. Vertical output circuit over amplified
   B. Vertical linearity adjustment not available
   C. Horizontal linearity adjustment not available
   D. Vertical integral circuit timing error

6. The picture shifts to the left side of the CRT but stable. Which is the trouble circuit?
   A. Horizontal AFC circuit
   B. Horizontal output circuit
   C. Deflection yoke
   D. Impedance damper

7. If the horizontal output transistor short, then:
   A. No picture, no sound
   B. No picture, but has sound
   C. Loss of horizontal sync
   D. One vertical line in the center of screen

8. If horizontal scanning is always reverse, what is the defective part?
A. Horizontal oscillator
B. Horizontal output circuit
C. Deflection yoke
D. Retrace blanking circuit

9. No color, but smear comes out when doing fine tuning. Why?
A. Color burst circuit no work
B. Color phase-shift circuit no work
C. Color demodulator no work
D. RGB grid circuit no work

10. If color drift on the whole picture, what do you need to measure first?
A. The voltage of color demodulator
B. The waveform of bandpass amplifier
C. The waveform of 3.58MHz
D. Check ACC adjustment knob

11. If colors show on the screen when receiving a B&W program, it means:
A. This is a super TV set
B. 3.58MHz is still working
C. Color killer circuit is no working
D. Color demodulator is out of order

12. Sometimes the color is excessive, sometimes weak. Why?
A. Tuner is not available
B. RF AGC is out of order
C. ACC is of no work
D. Bandpass filter is of no work

13. How to deal with the impurity of color?
   A. Do white balance adjustment
   B. Do focus adjustment
   C. Do color saturation adjustment
   D. Adjust the place of the deflection yoke

14. If the raster is purple, the cause may be in the circuit of:
   A. Green demodulation circuit
   B. Red demodulation circuit
   C. Blue demodulation circuit
   D. Both Red and Blue circuits

15. The major judgment principle for diagnosing the color circuit is:
   A. Check the existence of color burst signal
   B. Check the gain of color burst signal
   C. Check the gain of bandpass filter
   D. Check the output of the color demodulators
Part II. Describe the functions of the following parts of the diagnosis image pattern.

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 
APPENDIX D: LABORATORY PROBLEM 1 (VERTICAL CIRCUIT)

Please troubleshoot the defective circuit for the TV receiver.
Write down the defective component code on this sheet when you finish the troubleshooting work.

1: ____________
2: ____________
3: ____________

Time used: ____________ Judge's signature: ____________

The Schematic Diagram:
APPENDIX B: LABORATORY PROBLEM 2 (HORIZONTAL CIRCUIT)

Please troubleshoot the defective circuit for the TV receiver. Write down the defective component code on this sheet when you finish the troubleshooting work.

1:
2:
3:

Time used: __________ Judge's signature: __________________

The Schematic Diagram:
APPENDIX F: LABORATORY PROBLEM 3 (COLOR CIRCUIT)

Please troubleshoot the defective circuit for the TV receiver.
Write down the defective component code on this sheet when you finish the troubleshooting work.

1: __________
2: __________
3: __________

Time used: __________ Judge's signature: __________

The Schematic Diagram:
APPENDIX G: QUESTIONNAIRE

Please answer the following questions as soon as possible:

Scale assignment: Strongly Agree -------- SA(5)
Agree ------------------ A(4)
Neutral ---------------- N(3)
Disagree ---------------- D(2)
Strongly Disagree ------ SD(1)

A. Make only one choice for each question:

1. It is feasible to edit teaching material with image processing techniques ------ __ __ __ ___

2. It is profitable to learn TV troubleshooting with an expert-system-based courseware ------ __ __ __ __

3. The effect of image is better than that of text in instruction ------------------------ __ __ __ __

4. The image databased courseware is a useful and prospective teaching material ------- __ __ __ __

5. The expert-system-based learning style can save much time for learning complicated technical courses ------------------ __ __ __ __
B. Please express your opinions about DVI courseware:

1. In my opinion, learning TV troubleshooting with the aid of DVI expert-system-based courseware has following benefits:
   a: 
   b: 
   c: 
   d: 
   e: 

2. In my opinion, there are some deficiencies in this courseware that need to be improved:
   a: 
   b: 
   c: 
   d: 
   e: 
APPENDIX H: FUNCTIONS OF TV BLOCK CIRCUITS (COURSEWARE PART 1)

1. UHF and VHF TUNER:
Select the desired TV channel from the signals fed to it by the
antenna and converts it into the video IF.

2. AFT (Automatic Fine Tuning):
Automatically make fine-tuning adjustment.

3. Video IF AMPLIFIERS:
1). Provide most of the signal amplification of the receiver.
2). Provide the necessary selectivity and bandpass
    characteristics required to compensate for vestigial
    sideband transmission.
3). Minimize interference caused by adjacent channel picture
    and sound carriers.

4. SYNCHROUS DETECTOR:
Changes the high frequency IF into the composite video signal.

5. FIRST VIDEO AMPLIFIER:
Amplifies the composite video signal and acts like a signal
dividing center. The output from this stage provides signals for
the second video amplifier, the sync separator and AGC stage.

6. COMB FILTER AND VIDEO AMPLIFIER:
Provide additional amplification for the video signal and
separate the color signal from the B&W (Y) signal.

7. DELAY LINE:
Delay Y signal so that it arrives at the picture tube at the same time as the color signal.

8. THIRD VIDEO AMPLIFIER:
Provides sufficient amplification for the video signal so that it can drive the picture tube.

9. AGC:
Generates a noise-free dc voltage that is proportional to the strength of the input RF signal. The dc voltage is used to control the gain of the IF amplifiers.

10. SYNC SEPARATOR:
Separates the sync pulses from the composite video signal with a minimum of noise interference.

11. VERTICAL OSCILLATOR:
Generate 60 Hz (or 59.94 Hz) sawtooth voltage.

12. VERTICAL DEFLECTION OUTPUT:
Generates sufficient sawtooth voltage to drive the deflection yoke.

13. HORIZONTAL AFC:
Compares the horizontal sync pulses with the local horizontal oscillator output and generates a dc voltage that depends upon
any frequency error between them.

14. HORIZONTAL OSCILLATOR:
Generates the horizontal deflection sawtooth voltage (15734.264 Hz).

15. HORIZONTAL DRIVER:
Matches the horizontal oscillator to the output amplifier stage and provides proper drive.

16. HORIZONTAL OUTPUT:
1. Drives the horizontal deflection yoke.
2. Supplies pulses for AGC.
3. Supplies pulses for blanking.
4. Provides pulses for burst gate.
5. Provides ac voltage for the high voltage transformer.
6. Provides pulses for driving the scan-derived B+ supply rectifier.

17. DAMPER:
Provides the horizontal scanning for deflection on the left-hand side of the raster.

18. HIGH-VOLTAGE REGULATOR:
Keeps the high voltage that is fed to the picture tube constant under varying load conditions.

19. PINCUSHION CIRCUIT:
It is used to overcome a defect of deflection called pincushioning.

20. DYNAMIC CONVERGENCE CIRCUIT:
It takes a sample of the vertical and horizontal deflection voltages and combines them to form the correction voltages and currents used by the convergence assembly in order to compensate for misconvergence.

21. CHROMA BANDPASS AMPLIFIERS:
Amplify the chrominance signal fed by comb filter and drive the color demodulator.

22. COLOR KILLER:
It works like a switch that is able to turn on or turn off the bandpass amplifier. It turns on the bandpass amplifier when a color signal is transmitted and turns it off during B&W transmission.

23. CHROMA PHASE DETECTOR:
Compares the color burst coming from the burst gate with the 3.58 MHz signal generated by the local chroma oscillator. If any phase or frequency difference exists between these two signals, a dc voltage is generated that tends to force the oscillator into synchronism with the color burst.

24. CHROMA OSCILLATOR:
Generates 3.58 MHz subcarrier signal that was suppressed at the
transmitter.

25. COLOR DEMODULATOR:
Converts the chrominance signal (3.58 MHz) into R-Y, B-Y, and G-Y color signals (0.5 MHz).

26. RGB VIDEO DRIVERS:
1. Combines the -Y signal with the color difference signals and produces R,G,B signals.
2. Provides sufficient amplification to the difference signals to drive the color picture tube.

27. HORIZONTAL AND VERTICAL BLANKING AMPLIFIER:
Turn off the picture tube during H or V and color burst intervals.

28. LOW-VOLTAGE POWER SUPPLY:
Converts the ac line voltage into the required dc voltages to power the whole TV receiver.
APPENDIX I: FUNCTIONS OF TV ADJUSTMENT CONTROLS (COURSEWARE PART 2)

1. VOLUME CONTROL:
   Controls the audio signal level.

2. CONTRAST CONTROL:
   Adjusts the peak-to-peak amplitude of the composite video signal.

3. BRIGHTNESS CONTROL:
   Adjusts the overall light output of the picture tube.

4. VERTICAL HOLD CONTROL:
   Adjusts the vertical oscillator frequency.

5. VERTICAL HEIGHT CONTROL:
   Adjusts the amplitude of the vertical deflection sawtooth.

6. VERTICAL LINEARITY CONTROL:
   Adjusts the linearity of the vertical deflection sawtooth.

7. HORIZONTAL HOLD CONTROL:
   Controls the frequency of the horizontal deflection oscillator.

8. FOCUS CONTROL:
   Adjusts the dc voltage output of the focus supply, thereby adjusting the focus of the raster.

9. COLOR CONTROL:
   Determines the output amplitude of the chroma bandpass amplifier.
Its effect on color reproduction is to adjust the color saturation of the color picture.

10. COLOR KILLER CONTROL:
   Adjusts the signal level required to activate the color killer.

11. TINT CONTROL:
   Adjusts the phase of the local 3.58 MHz oscillator and thereby controls the resultant picture color.

12. MASTER SCREEN CONTROL:
   Adjusts the screen grid voltages of the picture tube as part of adjustment procedures used to obtain gray scale tracking.

13. RGB DRIVE CONTROL:
   Adjusts the grid to cathode bias of each electron gun of the picture tube and helps obtain proper gray scale tracking.
The following patterns are transmitted from the TV broadcasting stations and used for TV adjustment and troubleshooting:
APPENDIX K: TEST PATTERNS II (COURSEWARE PART 3)

The following patterns are generated from pattern generator and used for TV troubleshooting at the laboratory:

**Dot.** Use: Static convergence adjustments (at center of screen).

**Crosshatch.** Use: Dynamic convergence adjustments (at edges of screen).

**Horizontal Lines.** Use: Check vertical linearity; utilized in some convergence procedures.

**Vertical lines.** Use: Check horizontal linearity, utilized in some convergence procedures.

**Raster (Clear).** Use: Adjust focus; check color purity.
APPENDIX L: TV SYMPTOMS I (COURSEWARE PART 4)

The following symptoms are typical symptoms caused by the defections of TV vertical deflection circuits:

No Vertical Deflection

Insufficient Height

Poor Vertical Linearity
The following symptoms are typical symptoms caused by defects of TV horizontal deflection circuits:

- **Loss of Horizontal Sync.**
- **No Horizontal Deflection**
The following symptoms are typical symptoms caused by defects of TV color circuits:

- Poor Color Purity
- Excessive Color
- Loss of Color Sync.
- Colored Raster
- Color Shift
- 920 KHz Beat Noise
APPENDIX 0: COURSEWARE MODIFICATION PROCEDURES

The following procedures are used for editing the teaching material or modifying the existing courseware edited with PC Album packages. The user may learn these procedures according to the screen displays shown in the next few pages.

1. Select 'Database Access' from PCA master menu
2. Enter database name which you want to modify
3. Select 'Enter_Data' for input data to one subsystem
4. Select the data code number which you want to modify
5. Select 'Image' to change the image data
6. Select 'Live' to input a new image from a camera or a VCR
7. Save the data into database
8. Select 'View_Data' to view the saved data
Database=None

PC Album MASTER MENU

- Database Access/Reporting
  
  Create/Alter Database
  PAL Development
  Utilities
  Alter System Defaults
  Select New Database
  Exit PC Album

F1=HELP F2=Proceed

Database=None

PC Album MASTER MENU

- Database Access/Reporting

Current Data Drive: C:\PCDATA\n
Enter Database Name:

Press F1 for List of Databases

F1=HELP F2=Proceed
Database = NONE

Database Access/Reporting

Current Data Drive: C:\PCDATA\
Enter Database Name: TEST

Press F1 for List of Databases

F1=HELP  F2=Proceed

Database = TEST

Database Access/Reporting
  => Enter Data
  View Data
  Define/Produce Reports
  Utilities

F1=HELP  F2=Proceed
Database=TEST

Database Access/Reporting
  ➔ Enter Data
  View Data
  Define/Produce Reports
  Utilities

Enter Data
  ➔ Television
  tpv
  Adjust
  block

F1=HELP  F2=Proceed

Enter Data
Database=TEST

Television

No: Picture

F1=HELP  F2=Proceed  F10=Commands
Enter Data
Database=TEST
No: Television
Picture

Scrn_Chng View_Data Time/Date Image

Position cursor with TAB key to select Image Field
Database=TEST Television
No: Picture

Filename Live Capture Save Print Options
Data has been entered, Do you wish to Save the record? Y
Database=TEST Television
No: Picture

F1=HELP F2=Proceed F10=Commands
Enter Criteria:<()/>## ?
Database=TEST Television End
No: Picture

Press TAB to Edit
Database=TEST Television End
No: 10 Picture Full Diagram

F1=HELP F2=Proceed
F10=Commands
Database=TEST Television End
No: 10 Picture Full Diagram

Scrn_Chng Begin Criteria Update Delete Nested Enter_Data Time/Date Image

Position cursor with TAB key to select Image Field
Database=TEST Television End 05/31/90 21:47:06 KB>
No: 10 Picture Full Diagram

Filename Live Capture Save Print Options
define numeric(r, i, j, s)

proc raster
    display menu_box title('Raster')
    label('Raster is Ok')
    label('No Raster')
    label('Blooming')
    label('No Vertical Defection')
    label('Insufficient Height')
    label('Poor Vertical Linearity')
    label('Horizontal Foldover')
    label('Poor Horizontal Linearity')
    label('Loss of Width')
    label('Pincushion Distortion')
    label('Retrace Lines Visible')
    label('Rolling')
    label('Keystone')
    label('Other')
    input menu
    move status(menu) to r
exit proc

proc pic
    display menu_box title('Picture')
    label('Picture is Ok')
    label('No Picture')
    label('Weak Picture')
    label('Negative Picture')
    label('Loss of Vertical Sync.')
    label('Loss of Horizontal Sync.')
    label('Loss of both Vert. and Hori. Sync.')
    label('Poor Dynamic Convergence')
    label('No Channel Selection')
    label('Picture reach CRT but Deformed')
    label('Piecrust Distortion(Ringing)')
    label('Others')
    input menu
    move status(menu) to i
exit proc
proc colr
    display menu_box title('Color')
    label('Color is Ok')
    label('No Color')
    label('Weak Color')
    label('Excessive Color')
    label('Loss of Color Sync.')
    label('Wrong Color')
    label('Colored Raster')
    label('No Automatic Color Control')
    label('Poor Color Purity')
    label('Others')
    input menu
    move status(menu) to j
    exit proc

proc sound
    display menu_box title('Sound')
    label('Sound is Ok')
    label('No Sound')
    label('Buzz')
    label('Weak Sound')
    label('No Sound Control')
    label('Others')
    input menu
    move status(menu) to s
    exit proc
proc diagnosis
define numeric(temp)
  set criteria(clear)
call raster
  if r eq 0 then exit proc
call pic
  if i eq 0 then exit proc
call coil
  if j eq 0 then exit proc
call sound
  if s eq 0 then exit proc
compute temp = (r+10)*1000 + (i+10)*100 + (j+10)*10 + s + 50
if temp eq 16171 or temp eq 17161 or temp eq 18161 or temp eq 23661
  or temp eq 25161 or temp eq 13371 or temp eq 23761 or temp eq 13261
  or temp eq 12271 or temp eq 12291 or temp eq 12301 or temp eq 12421
  or temp eq 12341 or temp eq 12261 then clear screen
else move 100 to temp
  set mode(update data)
  set record(television) criteria( if number eq temp)
read first record(television)
display screen(television)
input keyboard
if temp ne 100 then begin
  set record(tpv) criteria( if number eq temp)
  read first record(tpv)
  display screen(tpv)
  input keyboard
end
exit proc
proc dlsblk
  display menu_box col(45) noclear
  title('Function of TV Block Circuit')
  label('Horizontal Driver')
  label('Horizontal Output')
  label('Damper')
  label('High-Voltage Regulator')
  label('Pincushion Circuit')
  label('Dynamic Convergence Circuit')
  label('Chroma Bandpass Amplifier')
  label('Color Killer')
  label('Chroma Phase Detector')
  label('Chroma Oscillator')
  label('Color Demodulator')
  label('RGB Video Drivers')
  label('Hor. & Ver. Blanking Amplifier')
  label('Low-Voltage Power Supply')
  label('Upper Pannel')
exit proc

proc dlsblk
  display menu_box col(5) noclear
  title('Function of TV Block Circuit')
  label('UHF & VHF Tuner')
  label('AFT')
  label('Video IF Amplifier')
  label('Synchronous Detector')
  label('First Video Amplifier')
  label('Comb Filter & Video Amplifier')
  label('Delay Line')
  label('Third Video Amplifier')
  label('AGC')
  label('Sync Separator')
  label('Vertical Oscillator')
  label('Vertical Deflection Output')
  label('Horizontal AFC')
  label('Horizontal Oscillator')
  label('Next Pannel')
exit proc
proc tvblkl
define numeric(t)
call disblk
call dimblk1
input menu
if last_key eq esc_key
 or status(menu) eq 15
then exit proc
else begin
clear screen
set mode(update_data)
move status(menu) to t
compute t = t + 14
set record(block) criteria( if number eq t)
read first record(block)
display screen(block)
input keyboard
end
exit proc

proc tvblk
repeat
  clear screen
call disblk1
call disblk
input menu
if last_key eq esc_key
 then exit repeat
if status(menu) eq 15
 then call tvblkl
else begin
clear screen
set mode(update_data)
set record(block) criteria( if number eq status(menu))
read first record(block)
display screen(block)
input keyboard
end
until 1 ne 1
exit proc
proc tvadj
repeat
  clear screen
display menu_box title('Function of TV Adjustment Controls')
label('Volume Control')
label('Contrast Control')
label('Brightness Control')
label('Vertical Hold Control')
label('Vertical Height Control')
label('Vertical Linearity Control')
label('Horizontal Hold Control')
label('Focus Control')
label('Color Control')
label('Color Killer Control')
label('Tint Control')
label('Master Screen Control')
label('RGB Drive Control')
input menu
  if last_key eq esc_key
    then exit repeat
  clear screen
  set mode(update_data)
  set record(adjust) criteria( if number eq status(menu))
  read first record(adjust)
  display screen(adjust)
  input keyboard
until 1 ne 1
exit proc

proc func
repeat
  clear screen
display menu_box title('Function')
label('TV Block Circuit')
label('TV Adjustment Controls')
input menu
  if last_key eq esc_key
    then exit procedure
  select status(menu) for
    when eq 1
call tvbik
    when eq 2
call tvadj
end
until 1 ne 1
exit proc
proc System(access)
    set record(television) criteria( if number eq 99)
    read first record(television)
    display screen(television)
    input keyboard
repeat
    clear screen
    display menu_box title('Select the Function you want')
        label('Pattern')
        label('Block Diagram')
        label('Diagnosis')
        label('Function')
    input menu
    if last_key eq esc_key
        then exit pcmanager pal(system_area)
    select status(menu) for
        when eq 1
            call pattern
        when eq 2
            call diagram
        when eq 3
            call diagnosis
        when eq 4
            call func
    end
until 1 ne 1
exit proc
proc pattern
define numeric(t)
    move 1 to t
    repeat
        set record(television) criteria( if number eq t)
        read first record(television)
        display screen(television)
        input keyboard
        if last_key eq esc_key then exit repeat
        compute t = t + 1
    until t eq 4
    exit proc

proc diagram
define numeric(t)
    move 10 to t
    repeat
        set record(television) criteria( if number eq t)
        read first record(television)
        display screen(television)
        input keyboard
        if last_key eq esc_key then exit repeat
        compute t = t + 1
    until t eq 14
    exit proc
APPENDIX Q: CFG FRAME GRABBER HARDWARE SYSTEM

Composite Video Signal → Sync Stripper → PLL

Sync

12 MHz clock

Analog RGB → ADC → DAC → Digital RGB

Hue

Sat.

Cont.

Digital RGB

3.58 MHz

Composite Signal → Video Decoder → 512 K Frame Memory

Video Encoder → Analog RGB

O/P

Digital RGB

IBM PC Interface

IBM PC AT.
APPENDIX S: PRETEST (IN CHINESE)

班別：__________  姓名：__________  學號：________________

在您作答之前，請先填好下列有關資料

下列科目是否學過：（在是否處打○）

1. 複雜電子技術         是□  否□
2. 電視原理             是□  否□
3. 電腦輔助教學CAI       是□  否□
4. 電子儀表             是□  否□

（一）根據一般彩色電視機常見故障，判斷最可能的故障部位。

_1. 標準畫面正常，無影像，無彩色。a. B＋低壓電源。b. 調諧器。c. 影像中頻。d. AGC
_2. 內有聲音，其它都正常。a. CRT電路。b. 影像放大電路。c. 徑直頻偏。d. 聲音電路
_3. 影像偏弱，其它都正常。a. 影像放大電路。b. 色度電路。c. AGC電路。d. 影像中頻
_4. 水平一掃線，a. 水平頻偏。b. 徑直頻偏。c. 同步分離。d. 聲音電路。
_5. 無色，其餘正常。a. 色度偏大。b. 色度電路。c. 消色電路。d. 影像中頻電路。
_8. 無畫面，無影像，無聲音。a. 低壓電路。b. 高壓電路。c. CRT電路。d. 水平頻偏。
_9. 只有聲音，其餘均無。a. 影像中頻。b. 影像放大。c. 高壓電路。d. 低壓電路。
_10. 出現相對掃描。a. CRT電路。b. 水平頻偏。c. 徑直頻偏。d. 調諧器。
_11. 出現彩色雪花。a. 調諧器。b. 色度偏大器。c. 消色電路。d. ACC電路。
_12. 失去色同步。a. 色相位檢波電路。b. 消色電路。c. 色度偏大器。d. 色解譯電路。
_13. 畫面邊緣集中不良。a. 聚集中電路。b. 動集中電路。c. 直流電路。d. 電子槍。
_14. 彩色與影像不一致。a. ACC電路。b. 水平同步電路。c. 3.5MHz頻偏器。d. 色解譯電路。
(二) 請寫出簡報圖中各部分所代表的意義：

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8.
APPENDIX T: POSTTEST (IN CHINESE)

(一) 選出最好的選項，把答案寫在題號前面。

1. 假如電視機的頻譜圖中作為故障診斷的參考，則當畫面很暗，且無色時，應該先調整何種旋鈕以幫助診斷？
   a. 亮度控制。b. 對比控制。c. 水平控制。d. 消色控制。

2. 如果電視機在正常接收時，有雜訊出現，則可確定故障部位為：
   a. 微調電路。b. 緩流電路。
   c. 高壓電路。d. 水平掃描電流。

3. 如果畫面呈垂直上下流動，則最可能的故障在：
   a. 垂直同軸電。b. 垂直標性調整。
   c. 垂直同步電路。d. 同步放大電路。

4. 如果畫面有時呈一側邊，有時正常，則最可能的故障原因為：
   a. 電阻器斷流。b. 電容器斷電。
   c. 電頻率衰多。d. 電路不穩定。

5. 如果畫面上下拉長，表示故障原因在：
   a. 垂直輸出電路。b. 垂直標性電路。
   c. 水平標性電路。d. 垂直標性電路。

6. 如果畫面向左側，但很穩定，則故障原因在：
   a. 水平AFC電路。b. 水平輸出電路。
   c. 高壓電路。d. 同步電路。

7. 水平輸出晶體短路時，故障現象為：
   a. 無影無聲。b. 無影有聲。c. 水平不同步。d. 垂直一直暗。

8. 若水平輸出晶體短路時，則故障原因為：
   a. 水平標性電路。b. 水平輸出電路。
   c. 垂直同軸電。d. 垂直標性電路。

9. 如果畫面無色，但調整畫面時有色斑，則最可能的故障原因為：
   a. 色階信號電路。b. 彩色移相電路。
   c. 色階信號電路。d. RGB相位電路。

10. 如果色彩鮮豔，應先測量：
    a. 色階信號電路。b. 色階信號放大波形。c. AGCK。d. ACC是否斷路。

11. 收視本機節目時，畫面仍有色彩，表示：
    a. 色階信號電路不正常。b. 色階信號電路仍有工作。
    c. 各機能正常作用。d. 色階信號電路故障。

12. 如果色彩閃動時有時淡，則故障原因為：
    a. 色階信號電路。b. RF AGC。c. ACC回路。
    d. 色階信號電路。

13. 如果色彩亮度不良，顏色混亂，則應如何處理？
    a. 色階信號電路。b. 色階信號電路。
    c. 色階信號電路。d. 色階信號電路的距離。

14. 如果畫面呈紫色，則故障原因在：
    a. 色階信號電路。b. 色階信號電路。c. 色階信號電路。
    d. 紅色與藍色信號電路故障。

15. 判斷色頻電路故障的主要依據是：
    a. 色階信號電路的有無。b. 色階信號電路的輸入信號電壓的大小。
    c. 色階信號電路的輸出信號相位。d. 色階信號電路的輸出信號相位。
（二）請寫出圖中各部分所代表的意義：

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 
APPENDIX U: SKILL TEST I (IN CHINESE)

實習問題（一） 壹直路故障診斷 LABORATORY PROBLEM

試根據所發給您的電路圖及電視機，找出故障零件。

零件一:
零件二:
零件三:

使用時間:

監試人員簽名:
APPENDIX V: SKILL TEST II (IN CHINESE)

勞動問題（二）水平電路故障診斷 LABORATORY PROBLEM

試根據所發給您的電路圖及電視機，找出故障零件。

零件一：
零件二：
零件三：
使用時間：
監試人員簽名：

![電路圖](image-url)
APPENDIX III (IN CHINESE)
APPENDIX X: QUESTIONNAIRE (IN CHINESE)

請根據您的經驗回答下列問題：

1. 我認為利用影像處理作教材之編制是可行的。（
2. 我認為電視機故障檢查可用專家系統實施基礎教學。
3. 我認為影像在教學上的效果比只有文字的效果大。
4. 我認為利用影像處理技術發展教學軟體比一般CAI更有發展進展。
5. 我認為專家系統的學習模式可以節省技術教學時間。

6. 我認為以影像處理方式學習電視故障檢查有下列優點：
   a. 
   b. 
   c. 
   d. 
   e. 

7. 我認為本學習系統尚待改進之處有下列各點：
   a. 
   b. 
   c. 
   d. 
   e. 

非同意不同意同意見同意意
Dear Sir/Madam: March 25, 1990

I am a graduate student pursuing a Ph.D. degree in Industrial Education and Technology here at Iowa State University. To meet the requirements for my degree, I am conducting a study of the effectiveness of microcomputer aided TV troubleshooting instruction using image processing techniques.

The results of this study will provide information to improve the teaching efficiency for the teachers who teach TV theory and troubleshooting in the teachers' colleges.

As part of this study, I will test the effectiveness of my newly designed courseware by comparing it to traditional teaching methods. Therefore, I respectfully request your participation. All individual information you provide will be kept confidential.

It is also hoped that you and your students will volunteer to participate in the project. Attachment enclosed are the procedure of experiment and the anticipated teaching unit. The proposed period will be from May 11th, 1990 to June 15th, 1990. The pretest and posttest shall be given to your students until the date that I meet with you. And the experiment will be implemented at your school shops.

Your cooperation will be highly appreciated.

Sincerely,

Chuang, Chien-Pen