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# A Study of the Uses of Expert Systems in the Training Environment

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A STUDY OF THE USES  
OF EXPERT SYSTEMS IN THE  
TRAINING ENVIRONMENT

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A RESEARCH PROJECT  
PRESENTED TO  
THE FACULTY OF THE COLLEGE OF EDUCATION  
OLD DOMINION UNIVERSITY

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IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE DEGREE  
MASTER OF SCIENCE IN EDUCATION

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By  
Edward Patrick Kappes  
August, 1990

This research paper was prepared under the direction of the instructor of Problems in Vocational Education, VTE 636. It is submitted to the Graduate Program Director for Vocational and Technical Education in partial fulfillment of the requirements for the Degree of Master of Science in Education.

A handwritten signature in cursive script, reading "John M. Ritz", is written over a horizontal line.

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## CHAPTER I

### INTRODUCTION

In 1956, the Dartmouth Summer Research Project on Artificial Intelligence (AI) was conducted with attendees from the major academic centers and think tanks in the country. The people who participated in the conference were mathematicians, psychiatrists, neurologists, and engineers. They came together in the hopes of influencing the government, private industry, and academic institutions in order to generate interest and to raise research money. The conference was a success and brought in a significant amount of financial support (Rothfeder, 1985, pp. 15).

The overwhelming support received was accompanied by high expectations by government, industry, and the public. Some of the researchers were acclaiming that soon there would be machines that would mimic the cognitive abilities of the human brain and therefore be able to reason and make decisions like humans. Unfortunately, artificial intelligence did not live up to the expectations that were brought on by some over-enthusiastic researchers. As the years went on and the research floundered, a great deal of the public enthusiasm was lost and artificial intelligence started to be thought of as an idealistic endeavor that had

little chance for success.

Many of the researchers did not give up but continued to diligently work on the problem of finding out how the human brain worked. Although they are still a long way from mastering the cognitive powers of the brain, there has been significant progress in the field of artificial intelligence.

Among the earliest researchers was Dr. Edward Feigenbaum a computer scientist widely recognized as the father of expert systems. Expert Systems (ES) are computer programs that are capable of holding vast amounts of data which can be manipulated by the user in order to solve problems with predictable outcomes. They are called "Expert" systems because they can incorporate the knowledge of a subject matter expert in their programs and this knowledge can be put to use by a novice. An expert system computer program attempts to capture the knowledge, experience, and expertise of the master in a particular field. Expert systems are being used today in many industries. For instance, the medical profession is using an ES, called MYCIN, as a tool in helping doctors and nurses provide the best care possible in a timely manner.

Expert Systems are changing the way companies do business and many human resource departments are very interested in the applications of expert systems in the training environment. In addition, many schools are putting this relatively new technology to use in the

classroom. Expert systems have the potential of becoming a multi-billion dollar industry in the near future. These systems are receiving wide recognition as valuable business tools and many companies are very interested in how they can use ES to make them more competitive in today's marketplace.

This study was done to examine the capabilities of expert systems, in order to determine their uses and limitations. Of particular interest were the uses of expert systems in the training environment.

#### STATEMENT OF THE PROBLEM

The problem of this study was to determine the usefulness of expert systems in solving training problems.

#### RESEARCH GOALS

The objectives of this study were:

1. To determine if expert systems can be useful in the training environment.
2. To show the types of training problems that expert systems can assist in solving.
3. To review the available literature to determine the applications of expert systems in the training environment.

4. To develop an experimental expert system designed to solve a training problem.
5. To test the findings by exposing an experimental population to the ES.

#### BACKGROUND AND SIGNIFICANCE

The field of computer science called artificial intelligence is experiencing a rebirth and people need to educate themselves so that they can take advantage of those new technologies. The area of artificial intelligence called expert systems is an area that is showing great promise in the training environment as a tool for promoting better quality training.

Whenever a product shows as much promise as expert systems do, then everyone wants to get a piece of the action. That is, companies come out with products and tend to stretch the truth a little when they talk about the capabilities of their product. Potential buyers and users have a need to know what types of problems can be tackled by a particular system or product. In addition, consumers have to be extremely cautious when buying these products.

Potential users of expert systems must be able to evaluate the performance of the systems. In addition, they need to know the kinds of problems that can be effectively solved by expert systems. That is what was attempted with this study; an effective means of

evaluating the uses of expert systems in order to allow potential users to make the right choice for their particular situation.

#### LIMITATIONS

The following limitations were applied to this study:

1. The products included in this study will be limited to those systems that can run on a personal computer.
2. The expert systems analyzed will be ones that have value in a training environment including on-the-job training.

#### ASSUMPTIONS

The following assumptions were necessary for the study:

1. It is assumed that there are some training problems that can be solved through the use of an expert system.
2. It is also assumed that for some training problems, ES represent an efficient solution.

## PROCEDURES

Vendors of expert systems were contacted and asked to provide data concerning their systems. Professional journals and other literature about expert systems were also surveyed. This information was compiled and conclusions were drawn. In addition, an expert system program was developed and included with the study to show how a training problem is selected and to test the effectiveness of ES. This system was one which could be used both on-the-job or in the classroom by a student.

## DEFINITION OF TERMS

To clarify the meaning of the words used in this study, the following words have been defined:

1. Artificial Intelligence (AI)-A sub-field of computer science that endeavors to develop machines capable of performing functions normally associated with human intelligence, such as reasoning, learning, and understanding human language.
2. Backward Chaining-A control strategy that regulates the order in which inferences are drawn.
3. Data Base-An organized collection of facts about a subject.

4. Expert System (ES)-A computer program capable of considering a vast body of knowledge, reasoning, and then recommending a course of action.
5. Forward Chaining-A search strategy used for processing knowledge bases in which solutions are inferred from known facts.
6. Heuristics-The high level, often imprecise rules of thumb and intuitive reasoning that experts use to solve problems.
7. Inference Engine-The component of an expert system that accesses, selects, and executes previously programmed rules. Sometimes referred to as a rule interpreter.
8. Knowledge Base-The part of an expert system that has declarative knowledge (facts) and procedural knowledge (rules).
9. Knowledge Engineer-Member of an expert system development team.
10. Neural Nets-Models of the human nervous system made of materials used in electronic components.
11. Shells-Software products that do not contain knowledge about anything. ES Shells are used to develop expert systems. Shells contain two

of the three necessary components of an ES;  
the inference engine and the user interface.

## OVERVIEW

This chapter examined a number of items. The problem of selecting an expert system and some of the capabilities of expert systems were presented. Also included was a short history of the artificial intelligence field leading up to the present day. The goals of the study were also discussed and the need for the study determined.

In Chapter II, the literature available on the topic was reviewed. Chapter III covered the development of the expert system used in the study and discussed how the data for the study was gathered. The fourth chapter presented the findings of the study. And Chapter V summarized the study, drew conclusions, and made recommendations to the reader about how he/she should use the study.

## CHAPTER II

### REVIEW OF LITERATURE

In the second chapter of this study a review of the current literature dealing with the use of expert systems and their applications in the training environment was conducted. The literature on the specific field of expert systems was limited. However, because the study is specific in its focus on Expert System (ES) uses in the training environment, only those ES with training applications were reviewed.

### SOME EARLY EXPERT SYSTEMS

The field of computer science from which expert systems came, is artificial intelligence (AI). In the AI field, there are three major areas of study that are interrelated-- robotics, natural language processing and knowledge-based or expert systems. Robotics is an area dealing with the use of robots to perform repetitive and sometimes dangerous tasks which in the past were performed by humans. An example of this area is the use of robots on the assembly lines at a car assembly factory.

The second area, natural language processing attempts to develop machines that understand and speak

our language. Knowledge-based or expert systems is the third area of AI and is an area in which large amounts of data can be installed into a computer program that can help the user make decisions and provide the reasoning behind why a decision should be made. Each of these areas warrants its own study; this study focuses on the knowledge-based or expert system area of AI (Kirrane, P., July 1989, p. 37).

Expert Systems (ES) have many applications and their shells are written in many different programming languages. One of the early, and still used, languages is LISP. LISP is short for list processing. It is a programming language that has the quality of being able to manipulate lists easily and many various operations can be performed on them (Levine, R., 1986, p. 226). Using these shells, complex expert systems can be developed.

Complex expert systems serve as "intelligent tutors" and can examine a learner's responses to create a model of their learning style. These tutors can assess the degree to which a learner has mastered a given topic and identify gaps in the learner's knowledge (Kirrane, 1989, p. 39). Having identified the gaps of knowledge, the system can teach the subjects what they need to continue learning effectively. Expert system tutors can be developed to teach complicated tasks and can identify an individual's problems on a

one to one basis. This ability makes these systems effective training tools. Banks and accounting firms are putting expert systems to work in helping some of their inexperienced workers process data.

With an expert system, an experienced professional can be continually questioned to obtain all the knowledge gained over their years of experience. All of this knowledge can be put into the system and inexperienced workers can use the system to make the decisions that the experienced worker would make. Not only can they do this, but the workers can question the system as to why they should make a decision and therefore, learn from the system.

An early expert system that was a major success and generated considerable interest was MYCIN. It was developed to diagnose and recommend treatment for blood infections (Knox-Quinn, C., 1988, p.12). In this system, the knowledge of expert physicians was put into the knowledge base. It not only would recommend therapy, but also allowed the user to ask why the therapy was being recommended and would give detailed explanation of its reasoning. In addition, knowledge could be added to the system to make it smarter, therefore the system had the capability to learn and expand its knowledge base the same way a human would through experience.

## EXPERT SYSTEM USES IN TRAINING

Expert Systems, Computer-Based Training, Intelligent Tutoring Systems and Intelligent Computer Assisted Training are all closely related fields of Artificial Intelligence. These areas are having an impact on the way we look at solving educational problems. Traditionally, evaluating educational problems and learning disabilities is done through the use of standardized tests and gathering pertinent data. This method can be enhanced by the use of an expert system to identify patterns of deficiency. One such system is called Learning Evaluation System (LES). This system organizes the process of evaluation systematically so a thorough and exact evaluation can be made (Levine, R., 1986, p. 135). It can be seen that the field of computer science is changing the way educators are conducting their business. Many of the changes in the area of computer science are changing the way we teach. Because computers are being more and more widely used in the training environment, the people who use them can not avoid learning from them. Students are almost forced to think logically when using expert systems. Most expert systems cause students to draw hypotheses through the use of If-Then rules.

The way that a expert system manipulates its data

is through the use of If-Then rules. A system asks questions of the user. By analyzing the answers given by the user, the system draws conclusions. These conclusions can then be scrutinized by the user. The user is allowed to ask the system questions to find out why it came to a particular conclusion and therefore the system teaches the user logical reasoning. An example of the use of If-Then rules used to reach a conclusion about where a family should take its next vacation follows:

```
IF    Budget = > $5000 AND
      Time = > 3 days AND
      Activities = family AND
      Country = USA
THEN  Destination = Disney World
```

WHY = Because Disney World is an excellent family vacation spot that takes at least three days to see and it is within your vacation budget limits.

In this simple example, that may be part of an expert system used at a travel agency, the conclusion is drawn using the information and preferences inserted by the user. The user could question the program's conclusion and the program would give a narrative about why it chose the destination it did. It could also ask the user if they wanted to change any of the variables. If they did, then the program would draw a new

conclusion from the new information.

Expert Systems can handle considerably more complex problems than the one shown above. Some medical expert systems can diagnose medical problems from information input by physicians. Using data about a patient's vital statistics, blood test results, liver functions tests, and so on, the program may suggest to the physician that the patient has liver cancer. One problem however, is that if the physician asked the program- What is cancer? or What caused this cancer?- the program may not be able to respond in an intelligent way. Many critics of these systems point out this fact and dismiss expert systems as mere textbooks of data.

However, look at the previous example from a training standpoint. At this hospital there is a doctor who has 20 years of experience diagnosing many health problems. This doctor is getting ready to retire and the hospital has 10 interns with very little experience. The hospital could spend time with the experienced doctor and a knowledge engineer to develop an expert system program that could contain all of the doctors knowledge and experience. When this program is completed, the interns could input data about patients and conclusions could be drawn. These conclusions would be the same conclusions that the doctor with 20 years of experience drew. Now the interns still have the benefit of the knowledge of a doctor with 20 years of

experience. These interns could ask the ES why a diagnoses was made and get instant answers. One can see that this program has the potential to teach the interns a great deal.

#### SUMMARY

The second chapter of this study examined several uses of Expert Systems and other related fields of computer science. There is a lot of information about expert systems and other related areas of Artificial Intelligence. However, there is a limited amount of data available dealing with expert system uses in the training environment. Therefore, the information gathered in this chapter shows that further research on expert systems and their applications in the area of training was warranted. In the next chapter, the methods and procedures used to conduct the study were examined.

## CHAPTER III

### METHODS AND PROCEDURES

The problem of this study was to determine the usefulness of expert systems in solving training problems. In this chapter, the methods and procedures were reviewed. By gathering and analyzing data about the field of artificial intelligence, particularly the area called expert systems, it was possible to determine whether these systems could be used in a training environment to solve training problems. In addition, it was determined that a valid way to test whether expert systems could be used effectively to solve training problems would be to identify a training problem, then develop a program that attempts to solve the problem. Discussed in this chapter were population selection, data collection, data analysis procedures and the experimental training problem.

### POPULATION

The population of this study consisted of the artificial intelligence programs available for use by training professionals. Specific emphasis was placed on those programs that came from the area of expert

systems. The study attempted to be even more selective by concentrating on expert systems developed specifically for the training environment. However, it should be noted that some of the programs analyzed were not designed for training purposes specifically but by nature had training applications. In addition to this data population, another population was involved in this study. This population consisted of a group of six electronics technicians that were tested after they completed the experimental expert system. These six technicians were students at a U.S. Navy training facility where they were being trained to maintain electronic systems. One of the equipments that the technicians were trained upon had a simple expert system developed for it. This system was to be used during troubleshooting.

#### DATA COLLECTION

Information about the field of artificial intelligence and particularly expert systems was obtained through library research. Many books, periodicals, and professional journals were consulted (see bibliography). In addition, commercial vendors were contacted and asked to provide information about their product and its applications in the training environment. The products were reviewed to see if they had training applications or if they could be

instrumental in achieving training objectives. Also, data was collected for an experimental expert system from a subject matter expert employed by Hughes Aircraft Company; his area of expertise is navigation electronics equipment. Because system down-time is a significant factor in evaluating the proficiency of maintenance efforts, the technicians were time evaluated when fixing similar problems both with and without the experimental expert system. Also, the students completed a knowledge test, the results of the knowledge test were compared to the test scores of all previously tested students to see if there was any significant difference. The results of these evaluations are presented in chapter four.

#### DATA ANALYSIS

Upon completion of the data collection and the development of the experimental expert system, all of the data was compiled and analyzed. The analysis consisted of comparing the results of the knowledge and down-time tests of previous tests and the same tests where the technicians used the experimental expert system. The findings of this analysis is presented in the following chapter.

#### SUMMARY

This chapter focused on the methods and procedures

used by the researcher to gather information about the possible uses of expert systems in the training environment. It discussed the data collection, data analysis, development of an experimental expert system, and the selection of population and information for the study.

## CHAPTER IV

### FINDINGS

This research project focused on the uses of Expert Systems in the training environment. Can expert systems be used to enhance traditional training? The research goals set forth in chapter one asked the following questions:

- 1) Are expert systems useful in the training environment?
- 2) What types of training problems can be solved by and in what instances can trainers find useful applications for expert systems?
- 3) Can an expert system be developed to solve a training problem and can it be tested?

### USES IN THE TRAINING ENVIRONMENT

There are many expert systems presently in use by major companies throughout the USA and the world. Here are a few examples of expert systems being used in training:

- 1) The IRS is using an expert system to help train its new auditors. The system helps people to recognize when deductions are valid and alerts auditors of the

types to situations where further scrutiny is warranted.

2) Both Ford and General Motors use expert systems that coach mechanics and technicians through difficult alignment and adjustment procedures. The more they use the system the more they learn about the cars.

3) The Air Force is using an expert system to help train pilots in mission planning, combat awareness, and target recognition.

(Frenzel, 1987, pp. 64)

#### APPLICATIONS OF EXPERT SYSTEMS

There are many expert systems in operation and development. They are being used in the following industries: consulting, finance, banking, science, medicine, engineering, communications, education, and the military.

#### EXPERIMENTAL EXPERT SYSTEM

An experimental expert system was developed for this research paper. The objective of the system was to enhance both the knowledge and skill level of electronics technicians in solving equipment problems. The effectiveness of the system in accomplishing its objectives was tested by comparing the test scores and completion times of an experimental group of students,

who used the expert system, with the scores and times of students who did not use the system. The results of the knowledge tests are shown in Table 1. The times for the two groups is shown in Table 2. Refer to Appendix 1 to find out how to set up and use the experimental expert system which is included with this research paper.

### SUMMARY

In this chapter the findings revealed by the research were reported. The objectives of the study were reintroduced and then answered in the three previous paragraphs and in Tables 1 and 2. The final chapter, Summary, Conclusions, and Recommendations, will present what was revealed by the study and make any recommendations deemed necessary as a result of the study.

TABLE ONE

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Knowledge Test Results

---

Average grade of all Navigation Interface Unit tests was 90.3%.

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Experimental Group Scores

Technician Number 1:	86.7%
Technician Number 2:	90.0%
Technician Number 3:	96.7%
Technician Number 4:	96.7%
Technician Number 5:	96.7%
Technician Number 6:	<u>100.0%</u>
Average Score:	<b>94.5%</b>

---

\* Knowledge Test consisted of 30 multiple choice questions.

TABLE TWO

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Practical Test Results

---

Average time for tests:

Practical Test Number 1:	27 minutes
Practical Test Number 2:	25 minutes
Practical Test Number 3:	19 minutes

---

Average time of experimental group:

Practical Test Number 1:	24 minutes
Practical Test Number 2:	20 minutes
Practical Test Number 3:	17 minutes

---

\* Practical Test consisted of a prefaulted electronic module which students were required to find and replace.

## CHAPTER V

### SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter will summarize the research and draw conclusions based upon the experiments and data collected throughout the project. In addition, the recommendations of the researcher will be presented.

#### SUMMARY

The problem of this study was to determine the usefulness of expert systems in solving training problems. In the first chapter, the study was introduced and the need for the study was established. The second chapter revealed some of the applications of expert systems and gave some examples of expert systems being used by the travel and medical communities. Chapter three focused on the methods and procedures used to conduct the research and discussed the development of the experimental expert system used by the researcher to judge the ability of an expert system to solve a training problem. In the fourth chapter, the findings of the study were reported. This chapter will tie all of the research done during the study together and will draw conclusions and make recommendations about the use of expert systems in the training environment.

## CONCLUSIONS

Expert System Technology is a rapidly expanding field that is helping many companies, including the military, to make their workers for more productive. The research completed during this study has shown that there are uses for expert systems in the training environment. Virtually any field in which an expert's knowledge base can be applied will benefit from an expert system.

The experimental expert system was easy to assemble using an expert system shell. However, the readers should realize that this was a simple system and that most expert systems will be considerably more complex to create and use. Most expert systems take months or even years to develop. Therefore, they can be very time consuming to create and very expensive. Even the experimental system took several weeks to complete and needs considerable refinement before it would be cost effective to use in the work place. However, this system could be the basis of a more complex system that could prove to be very useful. The experimental expert system did serve its purpose in this study by proving that a training application could be identified for which an expert system assisted in solving the problem or greatly enhanced the current training process. This system, though simple, showed that significant

gains in both knowledge and equipment down-time savings are possible. This can be seen by comparing the grades and times of the students who used the experimental system with the grades and times of the students who did not. The technicians, who had the benefit of using the program, scored an average of 4.2 points higher in their knowledge test scores and had an average time saving of 14%. These results could mean substantial savings for the users of expert systems. In the case of a vital military system, the down-time savings could make to difference between success or failure of a mission.

#### RECOMMENDATIONS

As a result of the findings and the accompanying research enough evidence has been presented to support the following recommendations:

1. Further research is warranted to identify specific training applications for expert systems.
2. Professionals in the training field should familiarize themselves with expert system technologies, in order that they may be prepared to implement these systems in the work place.
3. Expert System Technology shows a great deal of promise for use in the training environment. Trainers should endeavor to make use of them in their place of work now.

## APPENDIX ONE

This appendix will assist the reader in setting up the experimental expert system used in this study. The system must be run on an IBM or compatible computer. The computer must have a minimum of 512K RAM and a 5 1/4 inch double-sided 360K diskette drive. In addition, DOS 2.0 or higher is required of the computer. If the computer has a hard drive, the floppy drive must be designated drive A.

To load and run the expert system complete the following steps:

1. Turn on computer and allow it to load its system files.
2. At the A> prompt, insert disk labeled NIU.
3. Type "cd vpx" and hit the enter key.
4. At A:/VPX prompt, type "vpx" and hit the enter key.
5. Hit enter key when **CONSULT** is shown highlighted on the screen.
6. Hit enter when **NIU** is highlighted on screen.
7. Hit enter when **Go** is highlighted on screen.
8. Read the display and follow the directions on the screen to run program. The program will loop to allow user to repeat program.
9. To exit hit "8" twice at **Go**.

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