DOCUMENT RESUME

ED 265 686 EC 181 375

AUTHOR Hofmeister, Alan M.; Ferrara, Joseph M.
TITLE Expert Systems and Special Education.
SPONS AGENCY Special Education Programs (ED/OSERS), Washington, DC.
PUB DATE [84]
GRANT G008400650
NOTE 16p.
PUB TYPE Reports - Descriptive (141)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Artificial Intelligence; *Computer Managed Instruction; *Disabilities; Educational History; Elementary Secondary Education; *Special Education
IDENTIFIERS *Expert Systems

ABSTRACT

The application of artificial intelligence to the problems of education is examined. One of the most promising areas in artificial intelligence is expert systems technology which engages the user in a problem-solving diaglogue. Some of the characteristics that make expert systems "intelligent" are identified and exemplified. The rise of expert systems is reviewed, and selected present and potential applications of expert systems to the field of learning disabilities are presented, such as the development of an instructional prescription based on assessment information, the classification of students based on assessment information, and the selection of appropriate behavior management strategies based on classroom observational data. (CL)

Expert Systems And Special Education

Alan M. Hofmeister and Joseph M. Ferrara

Utah State University

Running Head: EXPERT SYSTEMS

Technical paper prepared with assistance of funds from the Special Education Programs, Department of Education Grant # G008400650. Project Officer: Jane Hauser

AI Expert Systems and Special Education

Artificial intelligence (AI) is an extensive field that has attracted the interests of a range of researchers and product developers. The field has been broadly defined as follows:

> Artificial Intelligence (AI) is the part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics we associate with intelligence in human behavior - understanding language, learning, reasoning, solving problems, and so on. (Barr & Feigenbaum, 1981, p. 3)

The Rise of the Expert System

The early years of AI research were associated with efforts to model broad-based human reasoning. These efforts were characterized by a belief that it was possible to identify a few basic laws of reasoning, couple those laws with the speed and memory of powerful computers and produce practical "intelligent" applications. These general-purpose approaches to problem solving proved to be too weak. When applied to specific problems, they were neither that intelligent nor that practical.

In reaction, a number of researchers de-emphasized general information processing. For them, the structure and nature of specific knowledge bases became a major area of interest. The terms knowledge engineering, and knowledge programming reflected this change in emphasis. As a result of this increased interest in knowledge bases, a number of knowledge engineer's efforts have achieved some success in replicating human expertise in specific areas. These developments have been termed "expert systems".

An expert system typically engages the user in a dialogue. This dialogue, in many ways, parallels the conversation a person might have with a consultant who has expertise in the specific area. The system interrogates the user, asking questions that will pinpoint the problem and the information needed by the expert system to suggest a solution. The expert system attempts to solve the problem using the information supplied by the user and rule based procedures that are specific to the knowledge area (Stefik, Aikins, Balzer, Benoit, Birnbaum, Hayes-Roth, Sacerdoti, 1983). Some expert systems will pose solutions and assign a confidence factor or probability level to the solution. If the information supplied by the user is incomplete, a solution with a reduced confidence factor may be presented.

Generally, the procedures used by expert systems have been developed after examination of examples of problem solving. These examples may be generated by one expert or a group of experts. The examples are studied to identify the underlying rules used by the experts in the problem solving or to verify the rules supplied by the experts. These underlying rules are combined to form the problem solving processes used by the expert system. It is not unusual for an expert system to use several hundred rules.

Expert System Examples

Expert systems have effectively generated rules and solved problems in a number of areas. PROSPECTOR, for example, is an AI program which is used in the field of mineral exploration. PROSPECTOR interprets soil and geological data and predicts the probable location of mineral deposits. In an experiment testing PROSPECTOR's effectiveness, users correctly predicted the location of a molybdenum deposit worth one hundred million dollars. Another AI program, MACSYMA was designed to solve a variety of complicated mathematical problems. Scientists and engineers access MACSYMA through a telephone network. Research chemists employ DENDRAL. Using mass spectral and nuclear magnetic resonance information, DENDRAL can identify a substance's potential molecular structure.

MYCIN, another well-known expert system, has led to educational applications (Davis, Buchanan, and Shortliffe, 1975). This program allows the user to feed in information on the characteristics of bacterial cultures and the patient's present symptoms. It then deduces the bacterial disease. In its initial form, this intelligent data base was used as a diagnostic tool by the physician. This same intelligent data base was then included in an intelligent

CAI program, NEOMYCIN (Clancy & Letsinger, 1981), designed to be used to teach the diagnosis of bacterial diseases.

When one examines the research and development being conducted in AI in different western countries and in the different areas of society, one void becomes very obvious. Although there are rather extensive developments in industry, medicine, and the defense department, there appears to be a comparative dearth of research efforts to apply AI to problems in public education in the United States (Sleeman & Brown, 1982; Roberts & Park, 1983). There are several reasons why educators have not been active in this area.

First, the technical and personnel resources necessary for the development of artificial intelligence (AI) products have, until recently, been rare and expensive. One report estimates that "fewer than half a dozen doctoral theses appear each year in some aspect of building knowledge systems" (Stefik et al., 1983).

Second, the long-term efforts necessary for AI product development did not fit the funding patterns for educational research. In referring to examples of effective expert systems, Winston (1979) noted that no one should look at these systems without understanding the "years of team effort that have gone into translating the basic strategies into working, useful systems" (p. 237).

Expert System Development Tools

Until recently AI research and development activities were not widespread. Today, however, research in artificial intelligence is no longer limited to a few basic researchers working in well-endowed laboratories.

The successful commercial and industrial application of a number of expert systems has led to the development of flexible AI tools which allow individuals with limited training in computer science to build expert systems.

Prior to the development of these tools, methods of knowledge programming were complex. Mastery of these methods usually required several years of study. The existence of development tools has reduced programmer training time. In addition, advances in hardware development have yielded more advanced and more affordable equipment.

Although sophisticated AI development tools are typically designed to operate on large computers and/or specialized machines designed specifically for AI development, there are AI tools which can operate on microcomputers (Teknowledge, 1984; Needle, 1984; Export Software International, 1984). Even the Apple IIe computer is being groomed for AI development and use. The December 1983, issue of A+ (an independent magazine for Apple computer users) carried a notice that by 1985, hardware and software which would allow for the development of AI programs on the Apple IIe would be available. Although the development of complex expert systems is still clearly not a project for a low power microcomputer, the existence of these scaled down systems appears to place expert systems development within the reach of public education.

The computer equipment needed to develop an expert system is often far more expensive than the equipment needed to use a finished system. An extended version of Interlisp, a programming environment designed to support artificial intelligence applications, has been made available for personal computers and a number of expert systems originally developed on more expensive machines have been made operational on microcomputers (Sleeman and Brown, 1982).

At least one AI development tool designed for large mainframe computers has taken advantage of the fact that the completed expert system can run on microcomputers. The Knowledge Engineering System (KES) is designed to download programs developed on large mainframe machines to microcomputers (Magliero, 1984).

In commenting on the reason for the recent dramatic increase of interest in expert systems, John Seely Brown (1984) observed:

> The answer rests not in the intellectual arena but in the recent dramatic advances in hardware. . . . Artificial-intelligence systems that required dedicated, million-dollar mainframes five years ago now can run on machines that cost only

$25,000. For the first time we have cost-effective delivery engines for expert systems, a major change. (p.82)

It is our assessment that low-cost versions of most popular minicomputers will be available within the next few years. Further, we believe that a wide variety of Expert System development tools for those machines as well as existing microcomputers will be marketed.

Potential Applications in Special Education

Hayes-Roth, Waterman, and Lenat, (1983) have documented the generic categories of knowledge engineering. Their listing places an emphasis on prediction, interpretation, diagnosis, remediation, planning, monitoring, and instructional tasks. A review of this listing indicates that a potential exists to match knowledge engineering approaches with problem areas in special education. The categories such as diagnosis, planning, and instruction are highly related to important special education activities.

In special education, potential problems might include: (1) the development of an instructional prescription based on assessment information, (2) the classification of a child into one of the special education categories (learning disabled, mentally retarded, etc.) based on assessment information, and (3) the selection of an appropriate behavior management strategy based on classroom observational data. Most situations where consultant help has value represent potential areas for the development of expert systems in special education.

When expert systems are used for direct instruction, the terms "Intelligent Computer Assisted Instruction" (ICAI) or "Intelligent Tutoring Systems" (ITSs) are sometimes applied to the products.

Expert system product development efforts can have at least three beneficial effects on the field of special education. First, an expert system teamed with a powerful small computer, can make low cost, computer consultant services available to classroom teachers.

A second benefit is the training value of the "intelligent knowledge base" generated by the development of the expert system. This knowledge base is a model of reality and can be used in the training of human experts. This training value has important implications in human service programs where simulation based training can reduce the threats presented to special education students by beginning instructors and diagnosticians.

Hofmeister (1984) developed an expert system "CLAS.LD" to provide a second opinion regarding the accuracy of the classification "learning disabled". To use the system, the user brings the psychological and educational information used by the assessment team to the computer and responds to a series of questions posed by the computer. The system operates on a high powered microcomputer. It is under study for its value as a consultant and as a clinical training resource where graduate students can test their diagnostic and classification skills against the expert system. The system uses Utah and federal regulations related to public law 94-142 in its problem solving processes. The expert knowledge base was built on the opinions of several nationally recognized authorities in learning disabilities.

A third benefit of AI product development is more subtle but just as important. In order to develop an expert system, knowledge engineers must organize and analyze the existing knowledge within a subject area. Expert system development could, in this way, accelerate the clarification and expansion of knowledge in Special Education.

The knowledge generation and clarification activities associated with AI product development have research implications of considerable value. At least two well-validated AI programs, DEBUGGY (Brown & Burton, 1978) and The Computer Guided Diagnosis of Learning Disabilities Prototype (Colbourn, 1982; Colbourn & Mcleod, 1983), have significant implications for special education.

In DEBUGGY, the knowledge generation aspect was significant. The developers of DEBUGGY added considerably to our knowledge of student errors in arithmetic. With DEBUGGY, the user is trained to identify error patterns in students' attempts at arithmetic problems.

Colbourn (1982), developed a prototype expert system which provided the user with a diagnostic report which could then be used in the development of a remedial program. The performance of this prototype program suggests that using an expert system for special education diagnosis is clearly feasible. After comparing computer-guided diagnoses with those of humans on 22 files, Colbourn and McLeod (1983) concluded:

> In general, the results of the evaluation were encouraging; the expert system's diagnoses were accurate. Furthermore, because of the system's speed at analyzing error patterns, its diagnostic reports included more information than those of the human diagnosticians. This was particularly noticeable with regards to the analysis of phonics skills. (p. 37)

Summary

During a presentation to congress, Bell (1983) made the observation that "Too much computer software is simply electronic page turning, and it has little advantage over a well-illustrated book" (p. 4). Artificial Intelligence represents a dramatic shift from "electronic page turning". It has been called the "fifth generation" or "second computer age," and it is characterized, not so much by increases in the power of hardware, but by dramatic increases in the sophistication of software. Feigenbaum and McCorduck (1983) observed that it is,

> . . . the important computer revolution, the transition from information processing to knowledge processing, from computers that calculate and store data to computers that reason and inform. Artificial intelligence is emerging from the laboratory and is beginning to take its place in human affairs. (p. 1)

We believe that artificial intelligence, particularly expert systems, can and should play an important role in the future of Special Education. This contribution would occur through (1) the increase in availability of expert system consultant services, (2) the use of the problem-solving models and associated software and knowledge bases for staff training, and (3) the clarification and expansion of knowledge bases as a result of the expert system development process.

References

Barr, A., & Feigenbaum, E. A. (Eds.). The handbook of artificial intelligence, (Vol. 1). Los Altos, CA: William Kaufman, Inc., 1981.

Bell, T. H. Computers and education. Statement made to subcommittee on Investigations and Oversights, House Committee on Science and Technology, U.S. House of Representatives, Washington, D.C., September 28, 1983.

Brown, J. S., & Burton, R. R., Diagnostic models for procedural bugs in basic mathematical skills. Cognitive Science, 1978, 2, 155-192.

Clancey, W.J., & Letsinger, R. NEOMYCIN: Reconfiguring a rule-based expert system for application to teaching. Proceedings of the seventh international joint conference on artificial intelligence, University of British Columbia, Vancouver, B.C., Canada, 1981.

Colbourn, M. J. (1982). Computer-guided diagrams of learning disabilities: A prototype. M. Ed. Thesis. Department for the Education of Exceptional Children, University of Saskatchewan. (ERIC Document Reproduction Service No. ED 222 032)

Colbourn, M. J. & Mcleod J. (1983). Computer-guided educational diagnosis: a prototype expert system. Journal of Special Education Technology, 6, 30-39.

Davis, R., Buchanan, B., & Shortliffe, E. Production rules as a representation for a knowledge-based consultation program. Report STAN-CS-75-519, Memo AIM-266. Computer Science Department, Stanford University, 1975.

Export Software International. (1984). Expert-Ease Users Manual. Edinburgh, U.K.: Author.

Feigenbaum, E. A., & McCorduck, P. The fifth generation. Reading, Mass.: Addison-Wesley, 1983.

Hayes-Roth, F., Waterman, D.A., Lenat, D. B. Building expert systems. Reading, Mass.: Addision-Wesley, 1983.

Hofmeister, A. M. (1984). "CLAS.LD". An expert system for classifying learning disabilities. Computer program for the IBMPC. Utah State University, Logan, Utah 84321.

Magliero, A. (1984). Review of Expert System Tools For a Prototype Project. (Available from Software Architecture and Engineering, Arlington, VA).

Needle, D. (1984, August). From the News Desk. Info World, p. 9.

Roberts, F. C., & Park, O. Intelligent computer-assisted instruction: An explanation and an overview. Educational Technology, 23(12), 7-12.

Sleeman, D., & Brown, J. S. Intelligent tutoring systems. London: Academic Press, 1982.

Stefik, M., Aikins, J., Balzer, R., Benoit, J., Birnbaum, L., Hayes-Roth, F., & Sacerdoti, E. The architecture of expert systems. In F. Hayes-Roth, D.A. Waterman, & D. B. Lenat (Eds.), Building expert systems. Reading, Mass.: Addison-Wesley, 1983.

Teknowledge Inc. (1984). M.1 Product Description. Palo Alto, CA: Author.

Winston, P. A. & Prendergast, K. A. (1984). The AI Business: Commercial Uses of Artificial Intelligence (p. 82). Cambridge, Mass: MIT.

Winston, P. H. Artificial intelligence. Reading, Mass.: Addison-Wesley, 1979.