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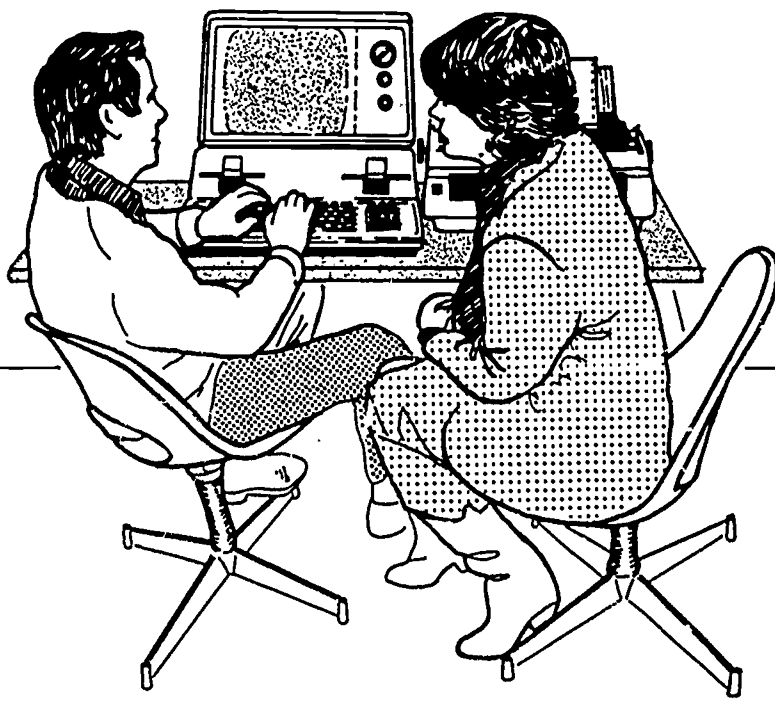
ABSTRACT

The paper describes the use of expert systems technology in translating test and observational data into objectives for Individualized Education Programs (IEPs) with handicapped students. The Math Test Interpreter (MTI) is designed to combine student information, results from the Key Math Diagnostic Arithmetic Test and additional program generated criterion referenced test data to produce a prescription in mathematics. The Behavior Consultant (BC) program applies the expert system approach to classroom behavior problems and features two videodisc components. Examples of a typical consultation with each of the expert systems illustrate their factual and heuristic rules and their use of backchaining to work from hypothesized conclusions to known facts. Possible system outcomes are delineated, including situations of inadequate information and development of objectives for IEPs. The paper concludes with a note on the implications of appropriate, clearly stated objectives for the education of handicapped students. (CL)

Technical Paper

Expert Systems in the Individual Education Program Process



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Expert Systems in the Individual Education Plan Process

Multidisciplinary teams must develop individual educational plans (IEPs) for handicapped children (Education for All, Sec. f.[a] [19]). The purpose of an IEP is primarily to guide the delivery of instructional services to a handicapped child (Dudley-Marling, 1985). The process of developing an appropriate instructional plan begins with collecting test and observational data. This information is used to determine each child's current level of performance. A planning team then proceeds to develop goals and objectives, which should match the student's performance. A review of the research has identified several problems which are associated with this element of the IEP process.

Problems in Moving from Data to Objectives

One such problem is related to the quantity and quality of information describing student performance. Thurlow & Ysseldyke (1979) found that a great deal of data describing student performance is collected, but much of it is technically inadequate and irrelevant. For example, student observational data, which is collected before an IEP meeting, often fails to operationalize behavior, appropriately quantify behavior, or list antecedent and consequent events. These limited observational records have little value for program planners. They are not specific enough to direct the development of goals and objectives.

Besides inadequate data, multidisciplinary teams often collect information irrelevant to instructional planning. Norm-referenced tests, used frequently in public schools to evaluate performance, can be considered instructionally irrelevant. A norm-referenced test produces a score that reflects how an individual's performance compares with the performance of other individuals. For a test to be instructionally relevant, an individual's performance must be assessed in absolute terms.

Criterion-referenced instruments, rather than norm-referenced instruments, assess student performance in specific, precisely defined content areas using absolute terms (Borg & Gall, 1979). Since criterion-referenced instruments can point out specific performance deficits, criterion- referenced tests can, therefore, be more useful to program planners than norm-referenced instruments to program planners.

An additional problem is that many instructional planners have difficulty moving from data collection to writing instructional objectives. Translating criterion-referenced test data into prescriptive objectives is a difficult task. The task, despite its level of difficulty, is critical to appropriate program planning. A student's program plan should directly relate to his current performance.

Authors and publishers of many criterion-referenced tests attempt to make the job of translating test data into prescriptive objectives easier by providing tables which reference specific objectives to test performance. For example, Connolly, Natchman, & Pritchett (1976) provide such reference tables for the Key Math Diagnostic Arithmetic test.

In spite of the Key Math developers' efforts to make the test prescriptive, Goodstein, Kahn & Cawley (1976) reported that Key Math has utility only as a preliminary screening instrument for assessing areas of strength and weakness in general mathematics achievement. Goodstein, et al. (1976) felt that the usefulness of the Key Math for diagnosis of mathematical disabilities and the prescription of specific intervention tactics remained limited. Furthermore, Goodstein et al. (1976) described Key Math objectives as too broad-based for most teachers to adequately develop a prescriptive program likely to meet individual student's needs.

Often skilled planners require more detailed and time-consuming, criterion-referenced test data as well as additional information to write suitable objectives (Colburn & McLeod, 1983). Many times, unskilled planners don't even know when to ask for additional information.

Although academic objectives are an important part of most IEPs, social skills must also be considered. For an IEP to be appropriate, objectives which relate to social skills must also be tied to a student's performance. This means that planners must translate observational data into objectives for social/emotional behavioral prescriptions. Since acceptable and unacceptable student behavior in the classroom often covers a much greater range of circumstances than those in an academic area, the problems associated with social/emotional elements of program planning can become very intricate.

There are at least two issues that limit the likelihood that planners will write appropriate instructional objectives in both academic social/emotional areas. First, inappropriate data are often collected. Second, planners often lack expertise that allows them to translate good data into prescriptive objectives. These two issues are interrelated because persons unfamiliar with handling data appropriately cannot request adequate information. Planners need adequate information to write appropriate objectives. Without this information, implementation of the IEP is severely hampered. Failing to correctly implement an IEP can be considered the most critical detriment to appropriate programming for a handicapped child (Gerardi et al., 1984).

Artificial Intelligence: A Possible Solution

The field of Artificial Intelligence, specifically expert systems, may hold solutions for the problems identified in the research.

Artificial intelligence is . e 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).

Artificial intelligence systems intended to replicate decision-making by knowledgeable and experienced humans are called expert systems. An expert system is typically set up to engage the user in a dialogue. This dialogue, in many ways, parallels the type of conversation a person might have with an expert consultant. The computer is programmed to ask the user questions to detail the problem or situation (Barr & Feigenbaum, 1981). For example, a well-known medical system for physicians is MYCIN (Davis, Buchanan & Shortliffe, 1975). With MYCIN the user inputs data into the computer information on the characteristics of the patient's bacterial cultures and the patient's symptoms. The computer is programmed to match the patient's data with information in the program on the characteristics of bacterial cultures and then, based on programmed logic, present a disease diagnosis.

Expert Systems and IEP Planning

Two prototype expert systems, Math Test Interpreter (Lubke, 1985) and Behavior Consultant (Ferrara & Serna, 1985) have been developed to test the feasibility of applying expert systems technology to the task of translating test and observational data into prescriptive objectives.

Math Test Interpreter (MTI)

The Math Test Interpreter (MTI) is designed to combine student information, results from the Key Math diagnostic Arithmetic Test (Connolly et al., 1976) and additional program generated criterion-referenced test data to produce a prescription for program planning in the area of mathematics.

The knowledge base of the MTI contains several components: (a) a set of rules to guide the consultation, (b) a master-set of objectives from which review and instructional objectives are selected, and (c) a set of criterion-referenced test items designed to obtain missing student information.

The MTI asks questions to gather information and then analyzes the user's answers by comparing them to the rules in the knowledge base. When necessary, the system prints out additional criterion referenced test items to gather more specific information about a student's performance.

Behavior Consultant (BC)

The Behavior Consultant (BC) program applies expert system technology to student behavior-problems in the classroom. Ultimately, two videodisc components will be associated with the BC expert system. The overall structure for BC will include: (a) an initial videodisc component designed to teach effective skills for observing student behavior; that is, to teach educators and others to be the "eyes and ears" of the system, (b) an expert system component designed to evaluate data from the user regarding student behavior-problems and suggest strategies for addressing the behavior-problems in the classroom, and (c) a second videodisc component designed to teach effective implementation of the behavior strategies recommended by the expert system.

Currently, the expert system component of BC is in the developmental stages while the videodisc components are in the planning stages. The current version of BC is designed as a microcomputer-based system. Because of the complexity anticipated for later versions of the expert system, it will ultimately be moved to a mainframe computer. This paper will show examples from the current BC expert system prototype. The basic structure employed in the current version of BC will also be used in later versions transferred to the mainframe computer.

Expert Systems Functioning

Consultations

Both prototype systems described above engage the user in a dialogue. For example, in the case of MTI, the user supplies information about the student such as grade, data of examination, mental ability, past math performance, IQ, chronological age, priority ratings for content areas, as well as item scores on the Key Math test. When consulting BC the user's answers to a series of questions describe the behavior-problems, the condition in which the behavior takes place, and the condition in which the teacher will attempt to modify the problem behavior.

Figures 1a and 1b present examples of a typical consultation with each of the expert systems.

Knowledge Base Rules

Both expert systems were written using a computer language that organizes human knowledge into a series of rules. These rules have two components: an "if component, or antecedent component, and a "then" component, or consequent component. When the conditions in the antecedent component of the rule match the conditions in the user's problem description, a conclusion in the consequent component of the rule is invoked. Figure 2 present an "if-then" rule taken from the MTI.

What was the student's age in months at the time the test was administered?

>> 12Ø.

What was the student's grade level at the time the test was administered? (Enter the score as a real number, for example 3.5 or 6.8.).

>> 5.1.

Based on your information about the student's intellectual functioning (IQ), this student would be considered:

-normally functioning (that is, above 75)

-intellectually handicapped (about 55-75)

-severely-intellectually handicapped (below 6Ø)

>> intellectually handicapped.

The three basic areas covered by the Key Math test are Content, Operations and Applications.

Please rate the CONTENT area in terms of priority, using a 1, 2, 3, with a "1" being the highest priority.

>> 2.

Please rate the OPERATIONS area in terms of priority,

>> 3.

Please rate the APPLICATIONS area in terms of priority,

>> 1.

How much time is devoted to mathematics instruction per day for this student? (Please enter the average amount of time per day in minutes).

>> 4Ø.

Figure 1a. Typical consultation with the Math Test Interpreter

What is the behavior which you wish to stop or retard?
>> talking-in-class.

Is there a good behavior which is incompatible with talking-in-class? (For example, speaking normally is incompatible with yelling. Working on math worksheets, on the other hand, is NOT incompatible with making strange noises).
>> no.

How quickly must the talking-in-class be stopped?

1. RIGHT AWAY! This talking-in-class is an immediate threat to the physical well-being of someone. (e.g., head-banging).
2. Quickly. This talking-in-class is making my life and/or the lives of the other kids miserable. (e.g., screaming).
3. There is no big rush, but I'd like to stop the talking-in-class as soon as I can. (e.g., talking in class).
4. The talking-in-class is only an annoyance. There is no need for a major effort to control it. (eg., nose-picking).

>> 3.

What consequent do you think is maintaining the talking-in-class?
>> teacher-attention.

Can the teacher control the teacher-attention which appears to be maintaining the talking-in-class behavior?
>> yes.

On a scale of 1 to 50, does the student enjoy being in the classroom where the talking-in-class is taking place?

He/she finds this to be an aversive place.	The classroom is among this child's favorite place

1--50
>>40.

On a scale of 1 to 50, does the student enjoy the activities taking place in the classroom while the talking-in-class is happening?

He/she finds these activities to be aversive	These activities are among this child's favorites

1--50
>> 40.

Figure 1b. Typical consultation with the Behavior Consultant

If IQ = intellectually handicapped, and

age = AGE

AGE = > 13, and

PAST PERFORMANCE = poor

Then EXPECTED PROGRESS = 7.5 months

Figure 2. An example of a rule from Math Test Interpreter.

MTI and BC programs contain factual and heuristic rules. Factual knowledge consists of information that can be documented, such as state and federal regulations and proven hypotheses (Feigenbaum & McCorduck, 1983). An example of a strictly factual rule would involve the calculation of the student's mental age based on the IQ and the chronological age input by the user.

Heuristic knowledge captures the "rule of thumb" experiences of humans. In special education, such knowledge might come from expert diagnosticians or instructors. Referring to the rule presented in Figure 2, it may be the heuristic opinion of several experts that under the circumstances described in the antecedent parts of the rule, a student would likely make seven and one-half months progress.

Back Chaining

Both MTI and BC expert systems use back chaining. This is a problem-solving technique which works backward from hypothesized conclusions to known facts. Thus, the expert system can determine if rules succeed or fail. For example, when testing the rule stated in Figure 2, MTI first seeks a value for the expression for "IQ." Then values for the expressions "AGE" and "PAST PERFORMANCE" will be sought. Thus, if all the conditions of a rule are confirmed, the conclusion is confirmed and the rule succeeds. Conversely, if any of the conditions in a rule cannot be confirmed, the conclusion cannot be confirmed and the rule fails.

There are three ways in which MTI and BC seek values for the expressions within rules. These systems' value-seeking behaviors are illustrated in Figure 3. When one system seeks a value for an expression within a rule, it will first check to see if it already knows the value. If it has previously asked or inferred the expression's value it will be stored in the system's global memory. If the system looks in the global memory and finds a value for the expression, it will stop looking and use that value to test the rule. If a value for the expression is not found in the global memory, the system will then seek rules which conclude with a value for the expression. The system will then test this next set of rules to identify the value of the expression. Finally, if there are no rules which conclude with a value for the expression, or if all such rules fail, the system will ask the user if he/she knows the expression's value.

Figure 4 shows how BC tests a rule, which concludes that time-out is an appropriate procedure for modifying "throwing objects" behavior. The steps used by BC in this situation are detailed below.

1. BC seeks a value for the expression "bad-behavior" in the global memory (the global memory contains information already acquired by asking the user questions).
2. Since the computer already had a value for bad-behavior stored in the global memory it returns the value "throwing" for the expression "bad-behavior." The expression "B" found in this condition indicates a variable. Thus, the value "throwing" is associated with the variable "B."

3. Next, BC seeks a value for the expression "speed(B)," that is, a value for the "speed at which throwing must be stopped." BC finds rules concluding with "then speed(B)" and tests the first condition of the first rule.
4. BC seeks a value for the expression "bad-behavior" in the global memory.
5. BC returns the value "throwing" for the expression "bad-behavior."
6. Because quickness does not have a value in the global memory the system seeks a value for the expression "quickness(B)" by asking the user a question.
7. BC returns the user's value "1-real-fast" for the expression "quickness(B)." Because the user's value "1-real-fast" does not match the value "4-real-slow", this rule fails.
8. BC enters "1-real-fast" in the global memory as the value for the expression "quickness(B)."
9. BC considers the next rule concluding "then speed(B)" and seeks a value for the expressions "bad-behavior" and "quickness(B)" in the global memory.
10. BC returns "throwing" and "1-real-fast" as the values for the expressions "bad-behavior" and "quickness(B)" respectively.
11. The rule concluding "then speed(B) = fast" succeeds.
12. The condition of the original rule stating "and speed(B) = fast" is confirmed.

13. BC seeks values for the expressions in the remaining conditions of the rule, that is, "time-out-ratio" and "child-characteristics." It finds these values either in the global memory, by testing rules, or by asking the user.

14. The rule succeeds or fails depending on the outcome of the expressions in the premises.

Possible System Outcomes

Inadequate information. Both BC and MTI can identify situations in which the data provided by the user either is inconsistent, lacks validity, or is incomplete. In situations where this is the case, the system will alert the user and suggest that additional information should be obtained. MTI will, in certain cases, print out specific criterion-referenced test items to be administered to the student. Two options are available at this point; the user may continue with the consultation, or the user may abort the consultations and gather the information needed to make a complete diagnosis and prescription. Figure 5 describes the output of this section of the MTI consultation process.

Objectives. Both MTI and BC are designed to print objectives for IEP development. MTI presents the user with two types of objectives, review objectives and instructional objectives. Review objectives cover those isolated skills a student appears to be lacking. The instructional objectives correspond with the level of the test items that fall at or above

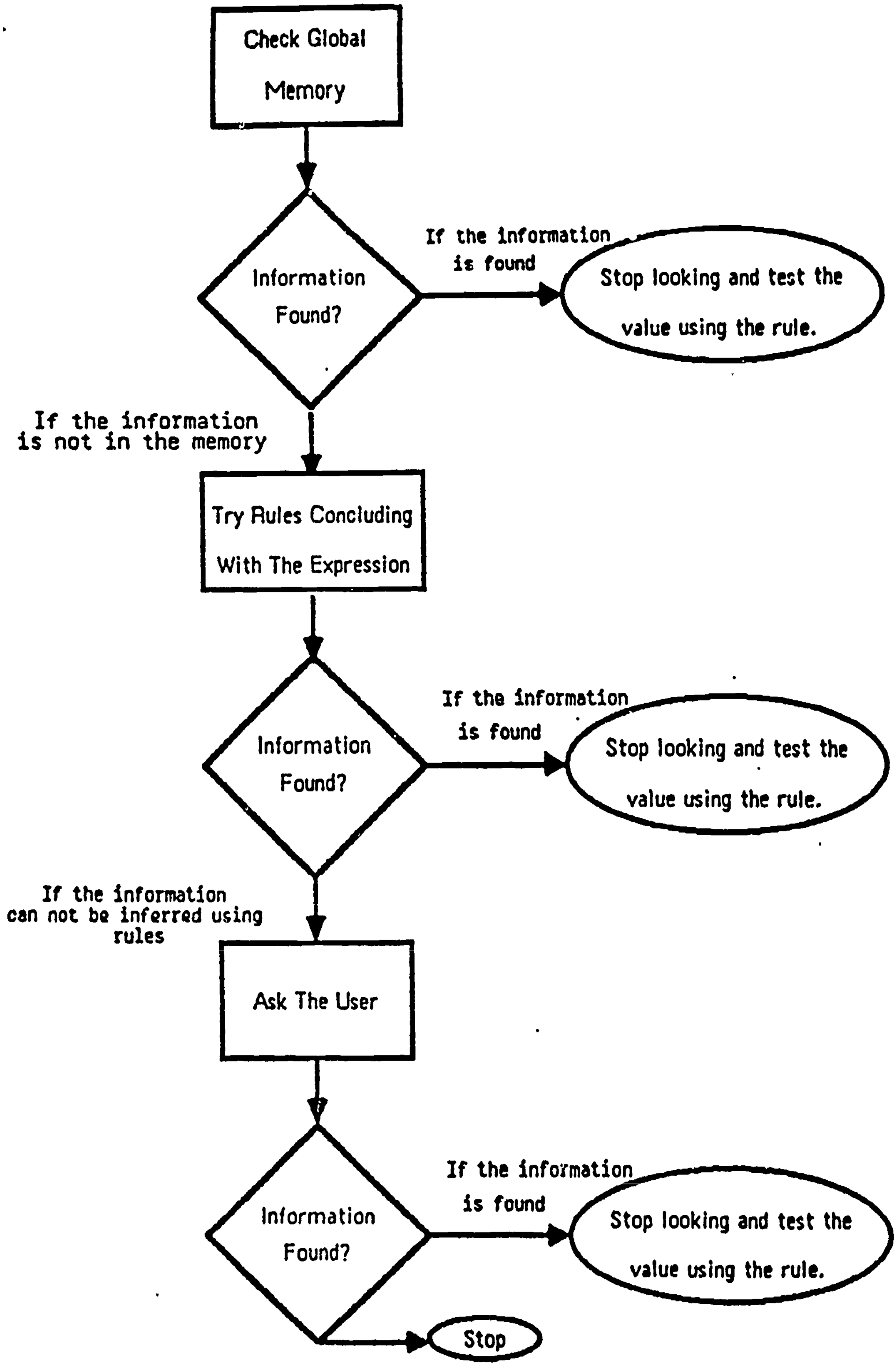

Figure 3. Three ways to obtain a value for an expression.

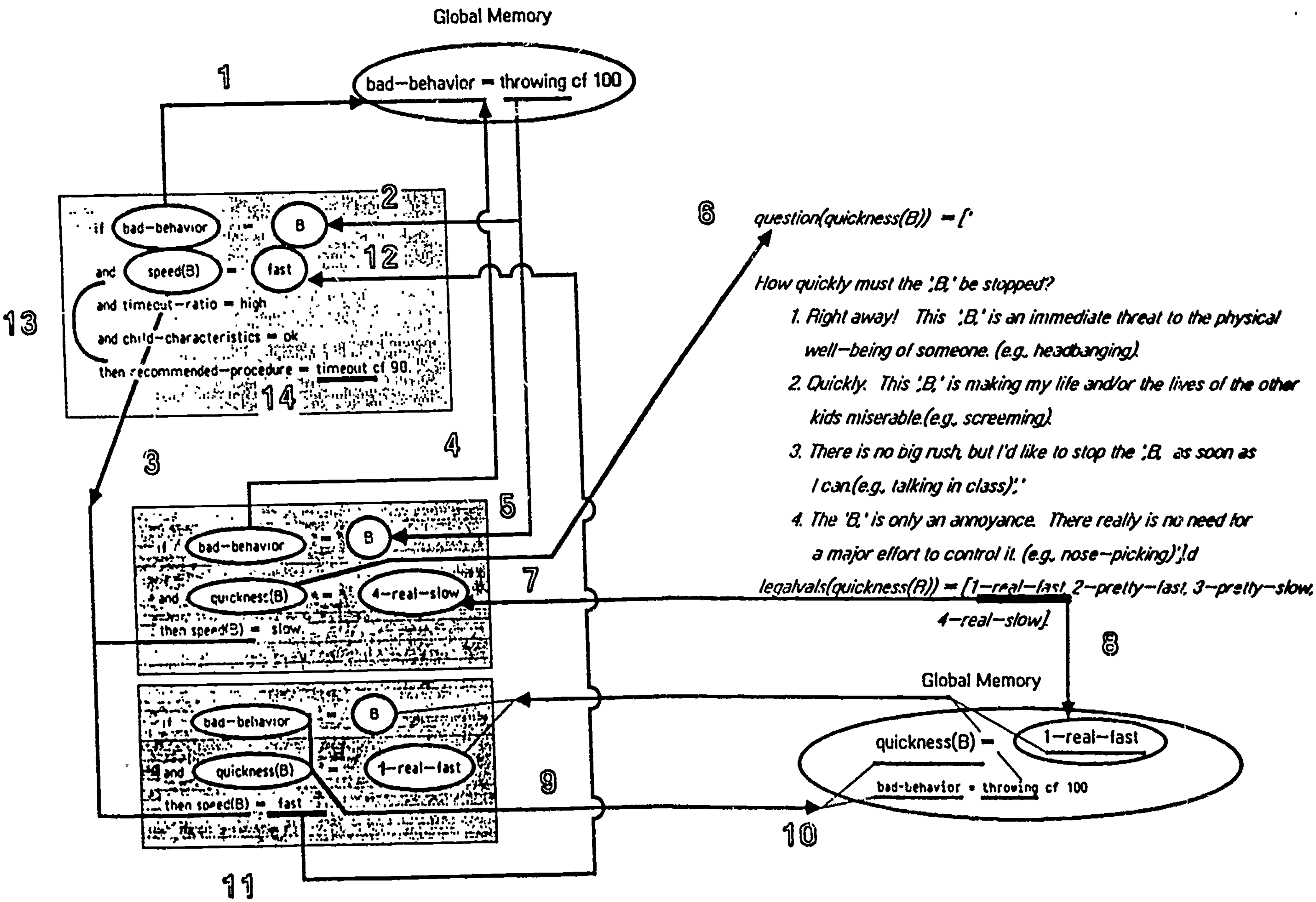

Figure 4. Example illustrating how Behavior Consultant tests a rule.

BEST COPY AVAILABLE

What is the value of item 4? (Enter a "1" if the student responded correctly to this item and a "Ø" if he/she failed to respond correctly).

>> 1.

What is the value of item 5?

>> 1.

What is the value of item 6?

>> 1.

What is the value of item 7?

>> Ø.

In order to determine the appropriate prescriptive objectives dealing with Identification and Addition of Coins and Currency, I need more information. It would be helpful if you would administer the following short criterion-referenced check with your student.

(Prints out check-test items on the printer).

Would you like to STOP and continue with this consultation at a later time or would you prefer to GO ON with the consultation without using the additional information?

>> STOP.

Figure 5. An example of a request for additional data from Math Test Interpreter.

the student's ceiling level. A student's ceiling level occurs when he/she has made three consecutive errors on the Key Math test. Figure 6 shows the screen display of the type of message presented to the user at the end of the consultation along with the appropriate objectives. These review and instructional objectives would be appropriate to include as short-term objectives in a student's IEP.

BC provides terminal objectives as well as an explanation of step-by-step procedures for achieving those objectives. When the entire BC system is finally completed in 1989, the computer will use an interactive videodisc to teach an instructor how to implement the suggested procedures.

Other General Features of Expert Systems

The M.1 authoring system (Teknowledge, 1984) was used to create both MTI and BC. M.1 has several features which make the system particularly attractive to educators.

1. The "TRACE" facility allows the user to monitor the computer logic as it attempts to provide advice.
2. The "WHY" facility allows the user to question the program about "why" it asked a question. The machine's response can be an M.1 rule, an English translation of an M.1 rule, or a reference to state and/or federal law.
3. The "SHOW" facility allows the user to query the program at any point in the consultation regarding its intermediate conclusions.

The student needs to review the following objectives:

3-A The student will verbally state in "cents" the value of a penny.

3-B The student will count out up to 2Ø pennies and verbally state the amount as ____ pennies.

4-C Given a nickel and five pennies the student will pcik out any combination of cents up to ten cents upon verbal instruction.

The following objectives are considered appropriate for the student's instructional level:

6-A The student will be able to match each amount with the correct corresponding amount written when using a dollar sign and a decimal point, given a worksheet with amounts written in cent form in one column.

6-B The student will be able to match the numerical values of money word values, such a $.5Ø with fifty cents.

6-C The student will be able to write the following dictated amounts using a dollar sign and decimal point--$1.2Ø, $.75, $2.68, $.62, and $.Ø5.

7-A The student will be able to select the quarter when directed to do so, given sets of coins containing pennies, nickels, dimes and quarters.

7-B The student will be able to indicate that another name for a quarter is 25 cents when shown a quarter.

7-C The student will be able to identify the one coin which is worth 25 cents when given sets of coins containing pennies, nickels, dimes and quarters.

Figure 6. Output of prescriptive objectives from the Math Test Interpreter

Summary and Conclusions

Expert systems and special education. Recent efforts to apply expert systems to the problems in special education represent a truly different approach. Considerable research is needed before firm conclusions can be reached regarding the value of expert systems for handicapped children. There are, however, some preliminary findings that indicate that this line of research is warranted (Hofmeister & Lubke, in press).

1. Evaluations conducted with prototypes indicate that these systems can perform as well as humans in specific areas.
2. Some of the problems faced by special educators are similar to the problems faced in other disciplines where expert systems have been successful.
3. The process of assembling and organizing knowledge bases for expert systems is a productive activity in its own right. The development of the "if-then" rules of a knowledge base clarifies existing knowledge and identifies areas where knowledge is needed.

Integrating expert systems into the IEP process. Paper compliance is relatively easy, that is, given the time-factor, fulfilling the "letter of the law" in writing IEPs can be accomplished with little effort. But, making a difference in the quality of a handicapped child's education, is a challenge that involves fulfilling the "spirit of the law." It is anticipated that expert systems like MTI and BC can upgrade the quality of the IEPs produced for handicapped children. With appropriate, clearly-stated objectives providers can plan daily instruction lessons that relate directly to the identified needs of their students. Today's handicapped children have "more rights" but the price they pay should not be "less quality education" (Gerardi et al., 1984).

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