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ABSTRACT

The purpose of this research was to design a model for constructing computer simulation sequences for use in developing future teachers' skill at questioning techniques, and to test the feasibility of using simulations in this context. The model developed involved a paradigm for classroom discourse which integrated selection of objectives, instructional moves, questioning behavior, and responses. A program was developed from the model and used with a group of students. Appendices list the moves and strategies used in the program and a set of questioning strategies exercises. (SD)

Interactive Computer Simulations for Sensitizing Mathematics Methods Students in Questioning Behaviors

by:

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ABSTRACT

Computer simulations can be used as a means for bringing theory into practice, through an "action" form. A rationale is given for the use of such a simulation. The design is discussed, including: (1) the theoretical background, (2) the conceptualization of the simulation, and (3) the program. Also discussed is the use and evaluation of the program.

Educational theory can be made more concrete for teacher education interns through the use of technology. Classroom simulations can be constructed so that interns "instruct" simulated pupils. Such simulations can synthesize theory and field research, thus bringing both theory and research into an "action" form for the intern. Interactive computer systems allow for active involvement through adaptive programs and can give immediate feedback to the intern.

There are four basic components in a simulation game: (1) an abstraction of an environment - this is the model, perhaps consisting of a system of models, (2) a series of rules for how the model behaves, or models interact - this is the simulation, (3) the freedom for the participant to interact with the simulation to develop strategies - this is the game, and (4) "reality" feedback - this is what makes it come "alive." An example of such a game is the subject of this paper. The abstraction of the environment is the activities that one does to teach a class; the rules for how the model behaves consists of how the sequencing of these activities interact; the intern manipulates the sequencing of these activities to gain insights into desired outcomes; and feedback comes in the form of the behavior of simulated pupils. In this case, a problem-solving approach was used to teach teachers how to use problem-solving approaches.

Purpose

The purpose of this study was to design a model for constructing such simulations and to test the feasibility of using such a program with interns. Feasibility was defined as the ability to design, develop, and utilize such a program that would yield effective results with interns.

Classroom simulations were developed for the PLATO (Programmed Logic for Automatic Teaching Operation) system at the University of Illinois at Urbana-Champaign, where methods students, henceforth referred to as "interns," "taught" simulated classes.

Rationale

For some time there has been considerable concern for more effective means to conduct teacher education programs. Many programs consist of theoretical courses and experiences of working with youngsters. Too often the intern fails to see the relationship between theory and practice. Theory often is not immediately followed with concrete examples actively involving the intern. Experimentation with live children can be very difficult for the totally inexperienced intern, as well as hazardous for the child and the intern. Interns often become easily discouraged.

Simulation activities are seen as a way of bringing relevance between theory and practice. A significant simulation, it is felt, forces the intern to manipulate the model to find the effects of various conditions. Also the participant should "live with" the situation that he has created, that is, experience and cope with the consequences of his choices and decisions. This technique allows interns the luxury of making professional errors without the often harsh real-life consequences.

In reviewing the literature, it has been found that simulation in teacher education is used in the following ways: video-tapes, role-playing as in peer group teaching, and uses of the computer. Video-tapes are passive and linear and do not allow for active interaction. Peer group teaching allows for interaction but the variables are very difficult to control. Interactive computer simulations allow for interaction, as well as control of variables so that the intern can learn desired insights and skills.

Design

The design for such a program used a systems approach, using a model that articulated models for: Henderson's moves and strategies, an approach to problem solving, various questioning behaviors, lesson planning, and a simplified learning theory.

Theoretical Background

The design followed the logical approach to teaching, advocated by Smith (1962), (1969) and Henderson (1963), (1967) in which a game theory analogy is used by examining the ideas of one move at a time, from one move to the next, and a sequence of moves, i.e., a strategy. Moves, e.g., instance, assertion, justification were analyzed for types of content taught, e.g., concepts (meanings of terms), principles (generalizations), and skills. Teaching strategies, i.e., sequences of moves, were also analyzed. For example, in order to teach a given principle one might give instance, instance, instance, assertion of principle, justification. A concept might be taught by a strategy such as: example, example, non-example, definition, example, non-example.

The approach to problem solving used in this study followed the idea of: Ask a difficult to answer question, ask a focus question, e.g., "How does one start to solve such a problem?" or "Look for a simpler related problem." eventually coming to examining simple instances of the original problem. Students can be taught this procedure, as exemplified by Wills (1967).

A synthesis of research on questioning was employed. For example, interns were encouraged to go beyond first responses of a simulated student by redirecting or probing.

The following ideas of lesson planning were written into the program:

objective of the lesson, motivation, subtask analysis, procedure and/or strategy, and evaluation.

As the intern "taught" the simulated class, the simulated students were to eventually achieve the objective. The number of instances needed for students to gain insight into a generalization was studied by Sowder (1970). He found that it required from 3 to 8 instances to discover the particular principle studied. He also found that brighter students learned faster.

Conceptualization

The following conceptualization was made. The intern was to "teach" a specific principle. First, he was to declare a specific objective to be completed with a simulated class, i.e., he was to declare whether he wanted the simulated students to: (1) Know the principle, (2) Apply the principle, or (3) Develop problem-solving strategies. He then proceeded to exert a logical move, by "asserting" a statement or "asking" a question. If he "asked" a question, he then interacted with simulated students. Options for various questioning behaviors were to be given, e.g., ask a question first or call on a student first, wait-time (the amount of time from when a question was asked until a student is called upon), and distribution of questions among class members. The intern then proceeded to the next move, and so on until he felt he had completed his objective (see Figure 1). Included also were to be options for deductive versus inductive and more motivational versus less motivational strategies, as well as the facility to "teach" needed subordinate information.

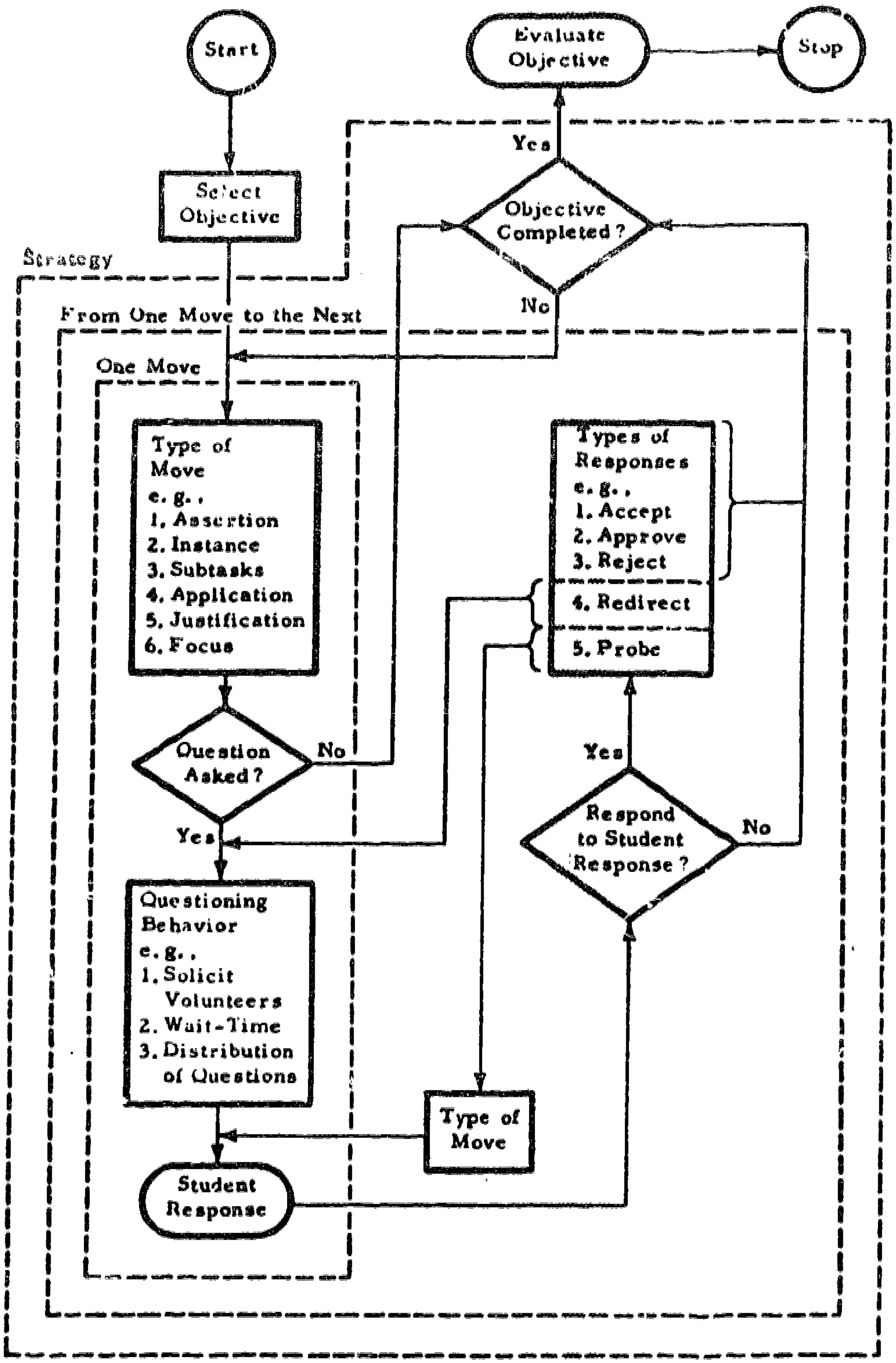

Figure 1. Paradigm for Classroom Discourse.

The Program

The above conceptualization gave the format for the program. A specific principle was selected, i.e., The sum of the first n odd positive integers is n^2. In order to "teach" the principle, a list of questions and statements was given to the intern. He could choose any question or statement at any time. He was to sequence such questions or statements in a form that was compatible with his declared objective.

How were the simulated students programmed to perform? Performances were determined by performance-level (PL) numbers assigned to the students. The numbers ranged from 0 to 20. Students with higher performance-level numbers were programmed to "perform" better in the sense that they "remembered" subordinate information (i.e., information needed to teach the lesson at hand - in this case they needed to know what an odd positive integer is) better and "learn" the principle with fewer instances. Simulated students with PL's higher than 15 were programmed to "remember" subordinate information; others were not. For example, if one were to ask "What is the sum of the first 3 odd positive integers?", the student must "understand" the concept of an odd positive integer. If this concept had not been taught, then simulated students with PL's less than 15 would ask, "What is an odd positive integer?" Hence, the intern was to realize that he needed to teach this concept.

How were the simulated students programmed to "learn" the principle? To program the students to "catch on" to the principle, results of Sowder's study were incorporated. Simulated students, with PL's larger than 15 were programmed to "catch on" after three correct instances; students with $5 \leq PL \leq 15$, "caught on" with an inverse proportional number of instances, e.g., PL = 12 required 4 correct instances, PL = 8 required 6 correct instances; students with PL's below 5 did not "catch on" but did understand the principle after "hearing" the assertion of the principle, followed by a couple of correct instances.

How was the intern to learn from the program? Feedback was given to the intern in several forms. Throughout the program the intern was given feedback in the form of "reality" by simulated student responses, e.g., responses indicative of whether students were "learning" the principle. A response indicating a need for subordinate information to be taught was described above. A response indicating that the intern has selected a less motivational strategy would occur about two-thirds of the way through the lesson, and would be in the form of "Why are we doing this?" At the end of the lesson, the intern was given additional feedback in two forms. One form was by another "reality" feedback of simulated students' performance on a mini-test relating the selected objective and teaching strategies employed, e.g., if the intern indicated that he was trying to teach for problem-solving abilities but used a deductive strategy, the results on the simulated test were very poor. Another form for feedback was a reflective analysis of the use of questioning behaviors. Interns were encouraged, through feedback, to go beyond first responses by redirecting and probing.

The use of counters, storage of data, and branching decisions made the above simulation possible.

Utilization of the Program

The feasibility of a computer-assisted instruction component not only depended upon the ability to design and develop a program, but also upon being able to use the program in such a way that effective results occurred. The final portion of this study was conducted with a class in "Introduction to the Teaching of Secondary Mathematics" taught in the spring of 1973. The procedure for using the computer program with this class, where each day consisted of two consecutive fifty-minute periods, was as follows:

Day #1 - Preparation for the Use of the Program

Interns had been given an assignment ahead of time to outline a sequence of questions to teach youngsters the principle: The sum of the first n odd positive integers is n^2.

Discussion took place concerning an orientation to the computer program and concerning Henderson's moves and strategies.

Handouts were given listing and explaining Henderson's moves and strategies (see Appendix A) and the computer program.

Interns were then told to keep the outline of questions that they had prepared and use them at the machine during the next class meeting.

Day #2 - Introduction to the Program

Interns were taken to a room in which there were PLATO computer terminals. The interns were given an orientation to the program. They were carefully directed through parts of the program that the researcher had found to give participants difficulty.

The interns then used their outlines to "teach" the simulated class. Afterwards they were asked to experiment with other ways of teaching the same principle.

Total time at the terminals this time was two hours.

Day #3 - Discussion of the Program and Introduction to Questioning

The interns returned to the class to discuss problems that they had encountered in using the program. Discussion was also given concerning the design of a questioning strategy and various types of questioning behaviors. The discussion was approached in a problem-solving manner by the researcher to exemplify to the interns as to how one might use such questioning techniques.

Interns were given handouts concerning Principles of Questioning and Polya's Approach to Problem Solving. Students were given an assignment (see Appendix B) that they were to work on at the machine.

Day #4 - Use of the Program

The interns spent two hours at the machine trying various questioning strategies and behaviors.

Day #5 - Use of the Program

Again interns spent two hours at the machine trying various questioning strategies and behaviors.

Day #6 - Discussion of Questioning

The interns returned to the class to discuss the ideas and/or problems that they had encountered. Also additional discussion was held concerning types of questioning behavior and their assignment.

Day #7 - Final Evaluation

Interns again returned to the machine for two more hours.

The researcher was in charge of all seven days of instruction. She felt that there should be a mixture of talking about desired behaviors and working at the machine, i.e., interrelating theory and concrete examples of the theory, and hence followed this principle during the seven days.

Evaluation of the Program and the Unit

Twenty-five interns were involved in the experimental class for which measures were taken prior and after the use of the simulation for approximately seven hours, and with intervening class discussions. Twenty-four out of 25 exhibited a positive attitude towards the over-all unit; 23 out of 25 increased their behavior of going beyond first responses; 19 out of 25 increased their modeling of the prescribed problem-solving strategy. Twenty-two felt that the individual components of the unit, e.g., the hand-outs, the class discussion, and the use of the program enhanced the learning of the other components. Twenty-two out of 25 indicated that they enjoyed the experiment; one student indicated that she did not particularly enjoy it, she did feel that it was worthwhile.

Many of the interns felt that the program helped them to sequence ideas better, be more aware of ways of reacting to student responses and student questions, be more aware of problem-solving strategies, as well as think more carefully about reviewing subordinate information and giving motivation. Overall the interns seemed to be getting what was intended for them from the program.

Sample comments made by students using this program are:

"It made me realize the importance of subtasks. It can be very disastrous to assume a class knows certain definitions and principles. One must make sure that they understand what is happening."

"Truly interesting and educational. Really got me excited about working with real 'victims.'"

"It made me think about the type of problems I would run into when trying to teach what seemed to me a simple principle."

"It was neat to get the individual experience of being on my own and planning my own strategy. Got much more understanding of strategy and all."

"I thought it was very worthwhile and valuable - and quite an enjoyable experience! Both computer sessions and class discussions have given me a greater insight into the role of the teacher and what will be expected of me."

"This was a worthwhile experiment for it gives us a chance to make mistakes and be evaluated immediately. This way we're not hurting any students' learning process because they were not real."

"No amount of talking, reading, or observation could have given me as much insight into planning, teaching strategy, reacting to student responses, etc."

Conclusion

Such a computer-assisted instruction component does indeed appear to be feasible. For a global view of a possible future of such work see "Interactive Computer Simulations - A New Component for Teacher Education."

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APPENDIX A

MOVES AND STRATEGIES

I. Move

A move can be thought of as an utterance that can be used to enhance learning. It can be giving or asking for a piece of information or reacting to a given piece of information. For example consider the following examples of moves:

A. Concept attainment[1]

1. Definition
2. Exemplification
3. Nonexemplification
4. Characteristic
5. Counterexample

B. Principle development[2]

1. Assertion
2. Instance
3. Justification
4. Application
5. Clarification, amplification
6. Counterexample

C. Reactions to student response

1. Approve
2. Accept
3. Reject
4. Redirect--ask for another student's opinion to a student answer
5. Probe--ask for amplification, clarification, information, evidence, or justification

II. From one move to the next move

Once one move has been made, one must consider where from there. Consider the following:

A. No student response involved

Go to next move--same kinds of choices as in previous list except, of course, it would make no sense to talk about a response to a student response as a next logical move.

[1,2]This is a condensed version of works by Professor K. B. Henderson.

B. Student response is correct

1. Approve
2. Accept
3. Redirect
4. Probe
5. Go to next piece of information

C. Student response is incorrect

1. Reject
2. Redirect
3. Probe
4. Ask same question of another student
5. Back up to an easier question for same student, i.e., rephrase, reshape.

D. Student question asked

1. Answer the question
2. Give the question back to the class
3. Redirect
4. Probe
5. Ignore or reject

III. Strategy[1]

A strategy can be thought of as a sequence of moves. Consider the following examples of strategies:

A. Concept attainment

1. Exemplification, nonexemplification, definition, exemplification, nonexemplification

   A set of examples of the concept is given. A set of nonexamples of the concept is given. The definition is given. Afterwhich more examples and nonexamples are given.

2. Exemplification, characterization, exemplification

   A set of examples of the concept is given. A set of characteristics of the concept is given. More examples are given.

3. Definition, exemplification

   A definition is given followed by a set of examples.

B. Principle development

1. Assertion of the principle, instances, justification

   The principle is asserted. A set of instance moves of the principle is given. A set of justification moves is given.

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[1]This is a condensed version of works by Professor K. B. Henderson.

2. Instances, assertion of the principle, instances

A set of instance moves is given or educed. The principle is asserted or educed from the students. More instances of the principle is given or educed.

3. Instances, assertion of the principle, justification

A set of instance moves is given or educed. The principle is asserted or educed. The principle is justified.

4. Assertion of the principle, clarification, justification

The principle is asserted followed by clarification moves, followed by justification moves.

5. Motivation, instances, assertion of the principle, application

A motivation move could be variety of types of moves, e.g., an application, a difficult or intriguing problem. After the problem has been posed one could follow it with instances of the principle, assert or educe the principle, follow up with application moves.

IV. Types of strategies

A. Deductive strategy

Assertion move comes early in the sequence and is usually given by the teacher. The assertion move is usually followed by combinations of exemplification and/or instance moves, clarification, justification, etc.

B. Inductive strategy

Assertion move comes late in the sequence if at all. Usually one tries to educe students to give this move and/or leaves the assertion at the nonverbal awareness level.

APPENDIX B

QUESTIONING STRATEGIES EXERCISES

In each of the following exercises make an outline of a sequence of questions[1] which are to accomplish the stated goal. Go to PLATO, teach the simulated class in lesson "strategy." Afterwhich do the discussion questions.

I. Objectives and strategies

A. Outline a sequence of questions (or statements) which will be used to achieve each of the following objectives (one at a time).

1. Given an n, the student can find the sum of the first n odd positive integers.

2. The student can apply the generalization to a problem.

3. The student is to develop problem-solving strategies.

B. Compare and contrast the sequences that you used in each of the above cases.

II. Subtasks and strategies

A. Outline a sequence of questions (or statements) which illustrate the following:

1. Gagné suggests that subtasks should be carefully analyzed and taught (or reviewed) first before teaching the task. Illustrate this in your sequence.

2. Bruner suggests that one should not specifically teach the subtasks first, but rather let them come up as they occur. Illustrate this in your sequence.

B. Compare and contrast the sequences that you used in each of these cases.

III. Motivation and strategies

A. Outline a sequence of questions (or statements) which illustrate the following:

1. A motivation is given early in the sequence.

2. No motivation is given.

B. Compare and contrast the sequences that you used in each of these cases.

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[1]In each case the topic is to be: The sum of the first n odd positive integers. See question choices.