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ABSTRACT

A series of computer programs designed to provide a dynamic simulator of Joyce and Weil's models of interactive teaching are described. Initially developed and tested at the City University of New York (CUNY), the system is capable of supporting retrospective and predictive analysis of selected kinds and patterns of verbal behavior in a variety of classroom settings. Initial data was gathered from 195 observations of 30 teacher trainees enrolled in the Preservice Childhood Education Program at Teachers College of Columbia University in the fall semester of 1971. In addition to the description of the simulator, its application and its supporting data, a review of the literature and earlier research on teaching behavior are also provided. (DGC)

A Computer Supported Simulator For Analyzing The Relationships Between Actual And Intended Teaching Behavior

Gary J. Confessore

Introduction

This is the report of a project in which systems methodology and techniques of computer simulation were applied to Joyce and Weil's models of teaching[1] to construct a software base for data collection, storage, treatment, and retrieval. The system is designed to be used in the development of a dynamic simulator of interactive teaching. In its present form the system is capable of supporting retrospective and predictive analyses of selected kinds and patterns of verbal behavior in a variety of classroom settings through batch mode processing.

The report is presented here in the belief that the entire CUNY academic community, and all others who teach, have a common interdisciplinary concern for the quality of their classroom interactions with students. The installation of a large central computing facility for CUNY puts the use of the model suggested here well within the reach of over 16,000 teachers and 250,000 students.

The project has had two main purposes up to this point. First, to develop and document a computer-supported model for collecting, storing, and retrieving data. Then, to develop and document working computer models for conducting retrospective and predictive analyses of certain kinds and patterns of verbal behavior in selected classroom settings. The initial base of data, collected to support the development of these computer models, is limited to those events recorded in 195 observations of thirty teacher trainees enrolled in the Preservice Childhood Education Program (PCEP) at Teachers College, Columbia University during the Fall semester of 1971.

No effort has been made to determine the effect of using these models on the subsequent verbal classroom behavior of teachers. Therefore, this report offers no empirical data related to hypotheses of the outcome of such use.

Review of Related Literature

The rationale for this project emanates from the literature available in four separate, but closely allied, areas of educational concern. First, a selective overview of the body of information related to the need for, and problems of, critical research into teaching behavior is presented as a foundation. Second, a brief sketch is included of the long standing plea of leading educators that teachers study teaching methods as well as content. This is to lend historical perspective to the present effort. Next is a presentation of general outlines of the literature related to the development and adaptation of verbal interaction analysis as an aid in teacher training, and finally, this is extended to include concepts of computer-supported simulations and gaming. These are included to familiarize the reader with the nature and scope of the specific "stuff" of which the present project is made.

1. Research into Teaching Behavior

Generations of teachers, and their trainers and supervisors, have attempted to identify and describe the salient characteristics of "good teaching." The underlying assumption for many in this search has been: Knowledge of what good teaching is like will facilitate the production of good teachers.[2] Despite the apparent rationality of this assumption, several lifetimes of research and millions of dollars expended in this pursuit have yielded only modest gains in teacher effectiveness.[3]

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Among the more negative spokesmen on this subject are Berelson and Steiner who, in 1964, summarized and dismissed research into teacher behavior as providing no clear conclusions, as empirically faulty, and as supporting only that which was already known as a matter of common sense.[4]

Less demanding is Eisner, who relates a variety of hypotheses which have been advanced with respect to the seeming fruitlessness of research into the nature of teaching. These include claims that "educational inquiry is much more complex than other types of inquiry and hence it will take more time to develop more effective methods of teaching";[5] that "the level of research competence of those working in educational research is too low";[6] that "educational research is dependent on research in other disciplines and cannot proceed faster than research in those fields"[7]; and that "educational research has for too long been concerned with descriptive studies and too little effort has been spent understanding how educational change may be most effectively engendered."[8] This last point is a primary concern in this project because a number of gains that have been made in the effectiveness of methods for *assessing* teacher competence are approached with an eye towards translation into methods for *improving* teacher competence.

2. Scholarly Teaching Behavior

Perhaps the single most important change in the field of education occurred when educational leaders began to move towards the conception of the teacher as a scholar of how teaching is done as well as of what is taught. It is difficult, if not impossible, to determine when and by whom the plea for scholarly (self-analytical) teaching behavior was first voiced. So, while acknowledging Socrates, Alcuin, Rousseau, and countless others, we move directly to the recent past since it seems more important here to emphasize the currency rather than the antiquity of this theme.

Witness the works of John Dewey[9] and George Counts,[10] which implore educators to think of teaching as a field to be studied as well as a function to be performed. Within the past decade, Martin Mayer has written:

> Given almost unimaginable good luck, American education could develop into a predominantly scholarly enterprise, in which the masters of a study would feel an obligation to communicate, and the teachers of children would seek out the uncongenial idea . . . Teachers could participate in the invention and propagation of teaching ideas, in the elimination of what is inconsequential, stupid, misleading, or unnecessarily difficult, and in the adaption of pedagogic models for differing groups of students.[11]

In 1967 Robert Schaefer called for more systematic inquiry into schools and schooling.[12]

As various notions of the teacher-scholar were conceived and tested, a plethora of training models and indicators of quality teaching were developed.[13] Diverse as these models are there is near unanimity on one point: *The ability to communicate with students is clearly one fundamental element in good teaching.*[14] This project focuses on the development of a model for building a system for analyzing the impact of employing a variety of responses in a given "stream" of communication data. In order to gather and treat such data in an empirical way, this project employs a verbal interaction analysis scheme.

3. Verbal-Interaction Analysis

When a new psychology caused our understanding of people to shift from a mechanistic to a humanistic view,[15] we were provided with the necessary environment for the spawning of a new research tool for the assessment of counseling behavior. Verbal-interaction analysis, originally developed to evaluate psychological counseling,[16] was soon adapted to teaching situation[17] and has since become widely used in the assessment of teaching behavior.

There are now almost two hundred schema for observing and analyzing verbal interaction in educational settings, each with its own strengths and weaknesses.[18] In their present state these tools allow educators to gather and analyze information about selected aspects of the verbal communications network as it functions in a variety of settings. For the most part, however, they discourage the formulation of value judgments about what is "good" and what is "bad" teaching behavior.[19] Rather, the various models afford a framework for discerning what occurred, verbally, during a lesson. The teacher is assumed to have some ideas of his own regarding what a good teaching situation ought to be, and he uses the results of systematic observations to check his verbal teaching behavior against his ideas of what good teaching is like. This assumption is borne out to some extent by Combs and Soper, who found that "*both* good and poor teachers are in essential agreement with expert therapists as to what an ideal (student-teacher) relationship *ought* to be like."[20]

In describing the multitude of assumptions made about communications in classroom settings and how each may serve as a point of departure for educational research, Greenberg makes the following provocative remark:

> The teacher speaks and assumes she is saying what she thinks she is saying. The students when quiet, are assumed by the teacher to be listening. If the students are listening, the assumption is that they are encoding what the teacher thinks she is saying.[21]

Verbal interaction analysis makes it possible to highlight some of the more dramatic breakdowns in this chain of assumptions.

These studies, and others, provide some evidence that verbal-interaction analysis is a practical aid in teacher self-assessment. Unfortunately, the conception of such activity as an aid in teacher self-improvement does not appear to have been, in Eisner's words, "effectively engendered."[22] Murphy argues:

> If teacher education programs are concerned that teachers can teach in a variety of ways and that they use strategies other than lecture and recitation, it is necessary to provide some specific training in other strategies. Merely telling the prospective teacher about other ways of teaching . . . is not sufficient to enable him to have these strategies as part of his available repertoire. *Opportunities to practice the new behaviors are also needed.* (Emphasis added)[23]

The point is, while verbal-interaction analysis may help a teacher determine the difference between what he *thinks* he is doing and what he *is* doing in class, it does not afford opportunities for testing ways of causing intended and actual behaviors to converge. Teachers can only guess what alternative mode(s) of behavior might have yielded the intended results. Such hypotheses can only be tested the next time a similar situation arises in class (if the teacher recognizes it).

If teachers are to take the time to assess their skills, they should have more solid grounds upon which to attempt the next logical step, self-improvement, than are presently provided by verbal-interaction analysis. What is needed, it seems, is a way of allowing teachers to recapitulate the events of a lesson in a manner which makes it possible to formulate and test ideas about what might have happened in the lesson being analyzed if they had acted differently in the first place.

One way of allowing such hypothesis testing would be to apply techniques of computer simulation to verbal interaction analysis. This could be done in a way which captures and fixes target events in a lesson so that selected relationships may be altered and examined without distorting the surrounding events.

4. Computer-Supported Simulations and Gaming

It may be helpful at this point to turn our attention to a brief discussion of what a simulation is and how we can make legitimate the use of simulation as a scientific tool.

When Herbert Simon was the Karl Taylor Compton Lecturer at Massachusetts Institute of Technology, in 1968, he found it helpful to use the words *simulated, synthetic, and artificial* as interchangeable equivalents. He did this to avoid what he called the "cheap rhetoric"[24] which, at that time, attended the exclusive use of any one of these terms. With this in mind it seems clear that we may freely substitute *simulated* for *artificial* in the four indicators which Simon used to distinguish the artificial from the natural in setting the boundaries of the sciences of the artificial. His indicators were:

1. Artificial (simulated) things are synthesized (though not always or usually with full forethought) by man.
2. Artificial (simulated) things may imitate appearance in natural things while lacking, in one or many respects, the reality of the latter.
3. Artificial (simulated) things can be characterized in terms of functions, goals, adaptation *(sic)*.
4. Artificial (simulated) things are often discussed, particularly when they are being designed, in terms of imperatives as well as descriptives.[25]

Within these limits is the science of simulation. Generally, it amounts to the imitation of some real world system. Once a simulation is constructed it may be used in attempts to increase our understanding of the imitated system. This is accomplished by testing hypothetical constructs in a variety of simulated, or imitated, environments. Cause and effect relationships in a simulation are normally stated in terms of mathematical probabilities. Put another way, a simulation is a collection of elements that have been taken directly from the real world and/or elements that have been constructed to faithfully represent real-world factors. These factors may be acted upon to determine the probability of selected cause and effect relationships. For example, a wind tunnel is a small system, faithfully constructed to account for the critical elements of systems in which an object must pass through an atmosphere. The results of studies using such a system may be used to make probability statements. These statements can be valuable in understanding and predicting the behavior of larger (real) systems of the same kind.

A. *Computing New Knowledge.* The digital computer, with its abstract character and symbol-manipulating generality, makes it possible to construct a wide range of imitated systems. The behavior of such systems can be studied through the technique of simulation. However, skeptics have argued that (1) simulations are no better than the assumptions built into them, and that (2) a computer can only do what it is programmed to do. Reducing their concerns to a single key question, they seem to be asking, "Can the computer function as a source of new knowledge?"

While the arguments noted above are undeniably true, the answer to the skeptics' key question must be affirmative. Simon dismisses the first argument by point out that

> even when we have correct premises, it may be difficult to discover what they imply. All correct reasoning is a grand system of tautologies, but only God can make direct use of that fact. The rest of us must painstakingly and fallibly tease out the consequences of our assumptions . . . We need the computer to work out the implications of the interactions of vast numbers of variables starting from complicated initial conditions. This is simply an extrapolation to the scale of modern computers of the idea we use when we solve two simultaneous equations in algebra.[26]

The second argument is much more subtle if we are biased by a preference for deductive formalisms. Nevertheless, Bertrand Russell seems to have accounted for it more than sixty years ago. He reminds us that

> the chief reason in favour of any theory on the principles of mathematics must always be inductive, i.e., it must lie in the fact that the theory in question

> enables us to deduce ordinary mathematics. In mathematics, the greatest degree of self-evidence is usually not to be found quite at the beginning, but at some later point; hence the early deductions, until they reach this point, give reasons rather for believing the premises because true consequences follow from them, than for believing the consequences because they follow from the premise.[27]

If we had not understood this, the top-down strategy that built the natural sciences over the past three hundred years would not have been acceptable. For instance, our understanding of the physical and chemical behavior of matter was fairly accurate even before we had knowledge of molecules. "This skyhook-skyscraper construction of science from the roof down to the yet unconstructed foundations," says Simon,

> was possible because the behavior of the system at each level depended on only a very approximate, simplified, abstracted characterization of the system at the level next beneath.[28]

Simulation, especially computer simulation, is a valuable and scientific tool *because* it accounts for these considerations, *not despite them*. The notion of programming a computer with abstractions of what we already know and then acting upon that information within the limits of assumptions (assumptions which are no more or less likely to be faulty than those made in any human effort) in the hope of revealing implications which will lead us to new understandings is surely in line with traditional scientific methodology.

B. Learning Through Simulation. The process by which humans, as well as lower forms of life, master skills and concepts is by no means clear. However, we have not been totally unsuccessful in our attempts to increase the rate at which mastery of some kinds of skills can be achieved and maintained.[29]

Skinner and others feel there is substantial evidence that mastery and retention relate directly to the number of repetitions and the frequency with which critical skills are elicited (practiced) and properly rewarded.[30] Teachers and educational researchers have taken the position that complex skills and concepts often become more manageable when they are approached in ways which allow consideration of the parts as well as the whole of the problem.[31] Simulations and games must be responsive to those notions. When they are, they provide a natural supplement to the more traditional forms of instruction. Some may be designed to allow the learner to act in ways which are analogous to the ways he would act in reality. Others may allow him to address isolated, well defined, simple (or simplified) representations of the critical components of the skill to be mastered. In either case, these analogs of reality may be practiced over and over until response habits are achieved. For learners who have already achieved some substantial degree of expertise, they support the maintenance of proficiency.[32]

Simulations and games may be developed to facilitate frequent and timely practice of skills which are needed infrequently, or in dangerous or expensive circumstances in reality.[33] For example, both new and experienced pilots use flight simulators to develop and maintain skills in procedures which involve specific and instantaneous responses. Many of the simulated conditions of flight to which pilots practice responding in this way are routine. Others would involve grave risk of life and property in reality and therefore can only be practiced through the simulator. Furthermore, the value of practicing responses to simulated emergencies is increased because many of these dangerous conditions arise so rarely in reality. It would be nearly impossible for most pilots to respond correctly in many real emergencies unless they had had substantial practice in responding to simulated emergencies.[34]

Another use of simulations and games, one which has more direct application to the problem at hand in this study, involves holding a variety of variables symbolically constant. The learner then acts on selected elements of the problem with which he is attempting to cope. In the first example the purpose is to *acquire the best response habit* in a given situation. In the second the purpose is to *test a variety of acceptable responses* to a single situation.[35] The present model is of the latter type. It is structured to allow users to isolate and manipulate symbolic representations of selected elements of the classroom verbal communications network.

C. A Taxonomy. Shubik suggests that a simulation or game may be thought of as falling into one of two categories according to the amount of control exerted upon the environment. He notes that

> in an environment-rich game the users do not assume that the environment or the rules can be totally described. There is a "free-form" aspect to the game. Rules must be invented and discussed as the game proceeds.[36]

There is often a great deal to be gained from the interaction generated in resolving the undefined elements of this kind of game. Therefore, computer support is generally not considered desirable.

On the other hand, computer support is often indicated for "environment-poor" games since the environment and rules are well defined. In Shubik's words:

> If the game is not computerized, in principle it would be possible to do so. The computerized game provides the players with a rigid simulation of their environment. It may be very complex, but all rules are given.[37]

In either kind of environment, simulations and games may be further categorized in terms of their functional nature. Clayton and Rosenbloom suggest that simulations and games generally involve participants in role-playing, the development and testing of strategies, or in analyses of structure.[38] Further, they point out that the compounding of these functions is not always desirable. For example, they believe it is often fruitful to combine strategy testing with analysis of structure.[39] However, they warn that

> role-playing and strategic analysis, rather than complementing each other, turn out to be incompatible behaviors: one requires immersion and the loss of perspective, the other requires stepping back and objectivity.[40]

In addition to categorization by environment, simulations and games may be categorized according to varieties of participation: whether participants act as cooperative or competitive teams, cooperative or competitive individuals, or as independent agents.

The software base that is operational at this point includes an environment-poor simulation in which participants act as independent agents to analyze structures and test strategies.

The Design of the Model

The model developed in this project consists of four major sub-systems. These are:

1. The Data Collection and Storage Subsystem
2. The Data Retrieval Subsystem
3. The Retrospective Analysis Subsystem
4. The Predictive Analysis Subsystem

The method and rationale employed in the construction of each subsystem and in the overall effort take the form of a ten point (element) model. The points of the model conform in most respects to general systems-development guidelines. Because of space limitations they are presented here without comment except for a brief description of the major subsystems they tend to form.

The elements of the model are:

Point One — The Establishment of Project Objectives
Point Two — The Selection of Protocol Materials
Point Three — The Organization and Training of Project Operatives

Point Four	The Establishment of Base-Line Behavior
Point Five	The Collection of Data
Point Six	The Coding and Storage of Data
Point Seven	General Analysis of the Data
Point Eight	Retrospective Analysis of Lessons
Point Nine	Predictive Analysis and Hypothesis Testing
Point Ten	Evaluation, Revision, and Extension of the Model

It should be noted that these elements are presented in a sequence which indicates the flow of the present project. This is done for purposes of exposition. They are, in fact, physically over-lapping, logically interdependent, and analytically inseparable as parts of a systematic whole. These ten points may be seen as falling into four larger categories or subsystems.

1. The Data Collection and Storage Subsystem

Data must be collected and stored in ways that are compatible with the statistical and operational methods one intends to apply to them. That is to say, data must be collected according to a protocol structured to insure that all necessary data elements are gathered in an empirically sound manner and that extraneous elements are ignored. Moreover, these data elements must then be stored in a form that interfaces appropriately with the plan for the data retrieval system and the data treatment system.

In this project 195 separate lessons were observed. The verbal interaction of each lesson was coded and recorded according to a modified version of the protocol described in the Teachers College Skills and Strategies Interaction Analysis System, 9/71.[41] This protocol was altered only insofar as phase initiation markers and subscript codes were omitted.

In order to facilitate data retrieval the coded observations were labeled according to eleven identifiers. The system user may use these labels individually or in any combination to group sets of observations into files of observations with key commonalities. The identifiers are:

A. Teacher identification
B. Task-type of the lesson
C. Sequency number of the lesson within the task-type
D. School-week during which the lesson was taught
E. Coder identification
F. Grade level of the students
G. Number of students to whom the lesson was taught
H. Subject of the lesson
I. Identification number of the cooperating or supervising teacher
J. Teacher's precision level at the time the lesson was taught
K. Teacher's responsiveness level at the time the lesson was taught

It should be noted here that item K (responsiveness) is a measure of the extent to which the teacher *apprehends* the student's frame of reference and modulates his behavior accordingly. Item J (precision) is a measure of the extent to which the teacher *changes* or modulates his behavior within the context of a teaching model.

2. The Data Retrieval Subsystem

In order to use stored data to the maximum advantage, a system for locating, unstoring, and grouping data elements according to the specific needs of the user, a comprehensive and flexible data retrieval system is necessary. The model developed in this project includes one such data retrieval system. It consists of a set of computer programs which make it possible to obtain the following kinds of data displays:

A. A linear, sequential display of the individual verbal events of the lesson(s) selected for analysis
B. A listing of the kinds of verbal events which occurred in the lesson(s) selected for analysis with the absolute and percent of frequency calculated for each
C. A listing of the kinds of verbal events which occurred at or above chance frequency in the lesson(s) selected for analysis with the absolute and percent of frequency calculated for each

3. The Retrospective Analysis Subsystem

This subsystem consists of computer programs which calculate and display some of the kinds of information which teachers and teacher trainers typically seek through the use of verbal interaction analysis. The principal purpose of this subsystem is to provide computer support to assist the user in placing past events in a time oriented series environment. This support speeds the user through the self-assessment dimension of verbal interaction analysis. The information made available through this subsystem includes:

A. Analysis of speakers—the percentage of *all talk* which is:
   (1) Teacher talk
      a. Teacher questions
      b. Teacher statements
   (2) Student talk
      a. Student questions
      b. Student statements
B. Analysis of the structure of the lesson(s)—analysis of the interaction involved in planning the lesson(s)
   (1)The percentage of *directed* and the percentage of *negotiated planning* of the *goals and standards* of the lesson(s).
   (2)The percentage of *directed* and the percentage of *negotiated planning* of the *context* of the lesson(s)
   (3)The percentage of *directed* and the percentage of *negotiated planning* of the *procedures* to be employed in the lesson(s)
   (4)The percentage of *directed* and the percentage of *negotiated overall planning* of the lesson(s)
C. Analysis of the information exchanged in the lesson(s)—the percentage of information which is coded as:
   (1) The factual level (Level 1)
   (2) The conceptual level (Level 2)
   (3) The theoretical level (Level 3)
   (4) Open
   (5) Opinion
D. Analysis of feedback—the percentage of talk which is coded as:
   (1) Positive feedback
   (2) Neutral feedback
   (3) Negative feedback
   (4) Corrective feedback
   (5) Repeat feedback
E. Analysis of additional event codes—the percentage of talk which is coded as:
   (1) Digression from the topic at hand
   (2) Events which are too unclear for normal coding.

4. The Predictive Analysis Subsystem

This subsystem consists of computer programs which may be used to support research into cause and effect relationships in classroom verbal interaction. It may also be used as a medium for practicing a variety of simulated responses to selected verbal situations in a controlled environment. These activities are seen as a means of moving towards a method for teacher *self-improvement*. The computer programs allow the user to:

A. Determine the extent to which the available data tend to account for a selected event in relation to the one or two events which precede it

B. Select one or two events and receive a statement of the frequency of the most common next event

For the purpose of this project "predictive analysis" has been defined as a process by which a researcher can test hypotheses about what verbal behavior is *likely* to follow selected verbal events. Further, it is intended to include a method of determining the probable impact of alternative modes of verbal behavior. That is to say, predictive analysis, as used here, means a way of projecting what would have probably happened at a given point in a lesson if the teacher had chosen to exhibit different verbal behavior in the first place.

In order to operationalize this definition three rather bothersome questions had to be considered. (1) How can reliable predictions of the consequences of altering a single verbal event in a lesson be arrived at when context is so vital to the understanding of each event? (2) Given the complex and unstable nature of the classroom environment and the many effects this may have on the behavior of teachers and students, how can such predictions be generalized from one situation to the next? (3) Assuming these two questions can be answered satisfactorily, how can predictive analysis and hypothesis testing contribute to teacher self-improvement?

Marsha Weil found some evidence of interest in consideration of the first question in the course of analyzing data gathered in a PCEP project similar to the present study. Her observations of lessons taught by teachers who scored at the extremes of the precision and responsiveness rating scale indicated that individual verbal events were acceptable predictors of next events. However, the value of pairs of events in predicting next events was dramatically lower.[42] This is not surprising when one stops to consider that under the coding system used there are eighty different single events, 6400 combinations of two events, and 512,000 combinations of three events in sequence. Verbal context apparently cannot hold up under such odds. Therefore, *it does not seem unreasonable to conclude that while context makes it possible to make reliable predictions of the consequences of altering a single event in a conversation, mathematics makes it nearly impossible to make defensible inferences based on context beyond that point.*

The search for a satisfactory answer to questions 2 and 3 was, to a great extent, what prompted this project in the first place. It seemed from the outset that some form of what Shubik called an "environment-poor"[43] simulation of classroom verbal interaction would make it possible to hold all other aspects of the classroom environment constant while selected events were altered for analysis. Predictions of the consequences of making such alterations become generalizable when it is recognized that in such a computer simulation a kind of "stop-action" and "instant replay" control can be exercised over the classroom environment and the target events. In such a simulation, hypotheses can be formulated and tested, and generalizations can be made, for under these conditions the computer's "memory" represents a true *tabula rasa*. With a computer-supported verbal-interaction simulator, teachers can practice a wide variety of responses to selected verbal events. Such practice should help teachers develop as broad a range of appropriate reflexes to the target events as is possible.

The Significance of the Project

This project is significant in that it represents the early steps in the development of a research tool which is responsive to the hopes of many researchers, expressed here by Joncich, that "educational research will clearly devote itself to finding out rather than to proving, to searching rather than to supporting, to investigating rather than to vindicating."[44]

The model developed in this project provides the users of verbal-interaction analysis with tools for conducting investigations into what they *might* have done in a lesson. This is a step beyond the usual use of verbal-interaction analysis which at present provides little more than evidence of what *was* done in a lesson. Such evidence can only be used to criticize or to vindicate the teacher.

This project is significant in that it provides educators with a tool intended to help them avoid what John Carroll called "regressive maneuvers"[45] in research. Carroll tells of three common activities which, in his opinion, are maneuvers to avoid the real complexities of experimentation. "The first regressive maneuver occurs," he suggests,

> when the investigator decides to do not an experimental study but a correlational study—an after-the-fact description of the results of treatment over which one has no real control.[46]

Verbal-interaction analysis is intended to preserve the dynamics of the classroom communications network for treatment after the lesson is completed. However, the dynamic properties of these data are indeed frail. The notion of extending the "half-life" of data collected in dynamic settings through the use of interactive simulation is offered here. Its realization should represent a significant step forward for educators who wish to extend the validity of studies of verbal interaction.

A second regressive maneuver, a more serious one according to Carroll, is employed when researchers make the decision to concentrate simply on methods of measuring phenomena, and thus avoid the entire issue of critically analyzing cause and effect relationships.[47] Verbal-interaction analysis in its present form is most certainly guilty of this. The introduction of computer-supported retrospective and predictive analysis capabilities may help some researchers avoid this pitfall in future studies into the verbal classroom behavior of teachers.

A most honored, but no less regressive strategy, Carroll continues,

> is to abandon any attempt to deal with empirical data and retreat into the cloisters which harbor those who concern themselves exclusively with methodological problems—with statistical theory, computational techniques, or mathematical rationales.[48]

While this project does not avoid such a pitfall entirely, the end product of this project may help others to avoid it in their studies of verbal interaction.

This project is significant from the practical point of view to the extent that it is addressed to a criticism of educational research which is aptly summarized by Ornstein. "Teaching," he argues,

> involves an on-going interaction between teacher and student, problems arise that must be dealt with on the spot, as they occur—research does little good at that moment: *since every situation is somewhat different*, feelings, insights, hunches, etc., seem more important. (Emphasis added)[49]

This project represents a first step in the development of a research model which will provide educators with "stop action" and "instant replay" capabilities of a sort. These capabilities allow the user of this model to analyze and alter his verbal teaching behavior in an environment which is, at least symbolically, identical with the original circumstances of the lesson. In this way many of the transitory elements of verbal interaction, which are of necessity treated as uncontrolled and uncontrollable variables at present, become constants.

Dewey argues that, "the student (student-teacher) adjusts his actual methods of teaching,...to what he sees succeed and fail in an empirical way from moment to moment."[50] If this is so, then the model developed in this project is significant in that it will provide a much needed controlled environment for practicing a variety of responses to a single classroom situation.

Uses of the Model

The true significance of this project resides in those things which can be done in the future as an extension of the software base constructed in this project. This section outlines a number of "what next?" steps which may enhance the impact of this project upon educational research and teacher training.

Kersh has called for

> supplementary experiences [which] should allow the student teacher to practice new behaviors without embarrassment or censure—to learn how it feels to be "tested" by the student, to try several different methods of handling a problematic situation, ..and to learn when to shift from one topic to another or probe deeper into the one under discussion.[51]

It seems reasonable to assert that the software base constructed in this project can be extended to uses in the clinical environment which Kersh has described here. For example, teachers may use an extended revision of the present model to master model syntax and learn how and when to make critical moves within models. Users may benefit greatly from such a combination of clinical and simulation experiences. Training of this type should help teachers to recognize or even anticipate student responses. Such skills would enhance their ability to lead rather than follow the students through learning experiences.

This notion might be operationalized through the development of a series of computer mediated instructional "frames." Picture, if you will, a teacher testing his skills with a teaching model at a computer terminal. As long as his moves are appropriate to the model he has selected, the program allows him to proceed. If he makes an inappropriate move or misses a critical cue, the program branches to a warning and requires the user to try another move. Such a program might also produce a report of elapsed time and a summation of modeling errors as incentives to make rapid and appropriate responses throughout the exercise. In addition, the report would provide documentation of progress and problem areas.

Two very exciting possibilities for further study have occurred to this observer. One involves applying the present model to a group of students in a study which assumes that models of teaching help teachers to teach. The major hypothesis is that these same models can help learners to learn.

Albrecht notes:

> When kids first come to the People's Computer Center (a center where anyone may use computer terminals free of charge) they usually play games. Sometimes for two or three weeks. But at some point almost every child asks, "How does the computer play these games?" "How can I write a game?" "How can I make the computer do this?"[52]

Then, in a conversational aside, Albrecht makes the following important point:

> The computer is intrinsically an information-doing-things-with device. And so it seems to me a very powerful toy for people to use—and once you get into it as a toy, you start doing some interesting things with it—and what's wrong with having fun while you learn?[53]

If Albrecht is right, it may not be unreasonable to conceive of students as researchers into the learning process. Their comments and insights into ways of improving a teaching model and/or a simulation could prove valuable to future researchers.

The other exciting possibility is a response to the age old question, "I wonder what would have happened if I had not done that?" Picture an extension of this model, supported by a massive data base and some rather sophisticated methods of projecting probabilities, such as finite Markov chains.[54] Such a model might make it possible for teachers and researchers to substitute alternative kinds of behavior at certain points in the event stream of a coded lesson and receive statements of what *probably* would have happened if the alternative kind of behavior had been exhibited in the first place.

In the final analysis, however, it seems that what is most needed to extend this model is an extension of the medium of computing. Forsdale points out that

> a prime criterion of the worth of any packaged educational material is that it should be available to the learner when and where and as often as he needs it. Materials which do not meet this criterion, whether for technical or financial reasons, are less than ideal.[55]

If we subscribe to this notion, accessibility of the end product must be a primary concern in any effort to extend this model.

Conclusion

Classroom verbal-interaction analysis provides a means of monitoring selected verbal activities of teachers and students within the context of specific taxonomies. That is to say, it provides a way of discovering how certain teacher actions correlate with certain student actions. This project has produced a tool for bringing the impact of computer-supported simulation to bear on that kind of activity. This tool facilitates efforts to analyze and reflect upon cause and effect relationships in classroom verbal-interaction. Such activities may well lead educators to new understandings of what represents effective and purposeful teaching behavior. However, its greatest promise lies in the opportunity for educators to practice (reinforce) selected actions. Through such reinforcement teachers will be able to go beyond finding out what teacher actions correlate with which student reactions and achieve more direct control over the verbal interaction of their lessons.

The steps which remain to be taken to develop a dynamic interactive teaching simulator from the present software base are rather simple from the point of view of research design. However, some of the practical problems of carrying out the one remaining step of real consequence may discourage all but the most dedicated and richly funded researchers.

Additional computer programs are needed to make possible the specific man-machine interactions desired. However, the final gap can only be closed with an adequate data base. These data should be gathered in two phases, both of which are likely to cost a great deal in terms of time and money. The first phase should be an effort to gather data which may be used to develop and evaluate ("debug") the specific functions of the simulation. During this phase one must be careful not to slip into poor research practices in order to resolve conflicts arising from the need to establish system balances (element weights). It is sometimes difficult to check the system's limits and responses to unusual streams of data without creating hypothetical data sets. To proliferate such hypothetical events in the data base would do more harm than good. This phase, therefore, requires the involvement of the broadest possible cross-section of teachers, students, teaching models, and classroom situations.

The second phase of data collection must yield only data which may be legitimately related to cause and effect projections *for the simulation user*. Therefore, these data must be collected in a very large number of observations of the narrowest possible group of teachers, students, teaching models, and classroom situations. For instance, one might follow the design developed in this project to create a dynamic simulator of interactive teaching for five to ten instructors in a given department. While phase-one data might be gathered in observations of every instructor in the school, phase-two data ought to be gathered by observing every lesson taught by each of the five to ten instructors who would become the eventual users of the simulator. Within a few weeks the phase-two data base would be larger than the one used in the present project. Moreover, it would have the added advantage of being specifically relevant to the user population. As the size of the data base increases, the project participants could begin to use the retrospective analysis subsystem and eventually the predictive analysis subsystem in attempts to cause their actual verbal classroom behaviors to converge with their intended behaviors.

Once the simulator is fully operational new users may be integrated a few at a time until all instructors in the school are able to interact with the system regardless of their discipline.

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