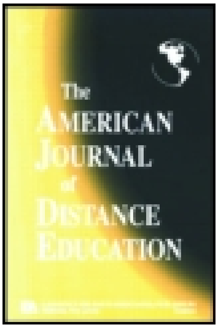

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Verifying key theoretical concepts in a dynamic model of distance education

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Verifying Key Theoretical Concepts in a Dynamic Model of Distance Education

Farhad Saba and Rick L. Shearer

Abstract

Theory driven, data-based, and empirical studies are needed to verify and solidify distance education's conceptual foundation. The project reported here had two main goals: 1) to empirically verify the concepts of transactional distance, structure, and dialogue, and 2) to develop a methodology for achieving the first goal. Drawing on three different fields—distance education, system dynamics, and discourse analysis—the project measured nine key variables in distance education. Results suggest that transactional distance varies by the rate of dialogue and structure, and demonstrate the value of system dynamics modeling for verifying theoretical concepts in distance education.

Introduction

Research in distance education has been primarily program based (Keegan 1990a). The literature in the field is rich with descriptive studies of programs, projects, and experiments in various geographical locations, at different educational levels, or in varying scales of implementation. Most data-based studies have been concerned with evaluating the results of such programs in terms of student achievements and cost-benefits. These studies have been essential for demonstrating the effectiveness of distance education systems to decision makers, funding agencies, students, faculty, administrators, and other stakeholders.

For the discipline to mature beyond its current stage, both as an academic endeavor and as a field of study, theory driven, data-based, and empirical studies are needed to verify and solidify its conceptual foundation. The project presented here was a step in this direction and had two main goals: 1) to empirically verify the concepts of transactional distance, structure, and dialogue (Moore 1980, 1983), and 2) to develop a methodology for achieving the first goal. An ancillary goal was to apply the methodology under development to the study of integrated voice, video, and data systems. This type of equipment is currently marketed as "desktop video conferencing" systems (Saba 1993).

The project drew from three fields: distance education, system dynamics, and discourse analysis. Moore's 1973, 1980, and 1983 studies were the sources of key concepts for this project. In his 1973 study, Moore identified three "sub-systems" in an independent learning and teaching system: a learner, a teacher, and a method of communication. In his 1983 study, Moore proposed a theory of distance education that defined distance in terms of the "responsiveness" of an educational program to the learner, rather than in terms of the physical separation of the instructor and the learner. System dynamics was selected for conceptualizing the relationships among the key variables and for simulating the temporal dynamics (time-based variance) of such interrelationships. Analysis of the discourse between the instructor and the learners provided the means of measuring the variables under study and the raw data for simulating the interrelationships of the variables.

A Theory of Distance Education

In 1980, Moore introduced the concept of *transactional distance* and defined it as a function of two variables, *dialogue* and *structure* (Moore 1980). Dialogue is "the extent to which, in any educational program, learner and educator are able to respond to each other"; structure is "a measure of an educational programme's responsiveness to learners' individual needs" (Moore 1983, 171). Transactional distance was defined as a function of the variance in dialogue and structure as they related to each other; from this perspective, "distance" in education is not determined by geographic proximity, but rather by the level and rate of dialogue and structure (Moore 1983; Saba 1988).

In 1988, Saba proposed a system dynamics model to represent the relationship among these variables. This model assumed a systemic and dynamic relationship between dialogue and structure, and suggested how a learner and a teacher, by varying the rate of dialogue and structure, could control the level of transactional distance in a purposeful instructional setting. This relationship is illustrated in the causal loop diagram in Figure 1. The present article reports the results of a study to empirically verify this model.

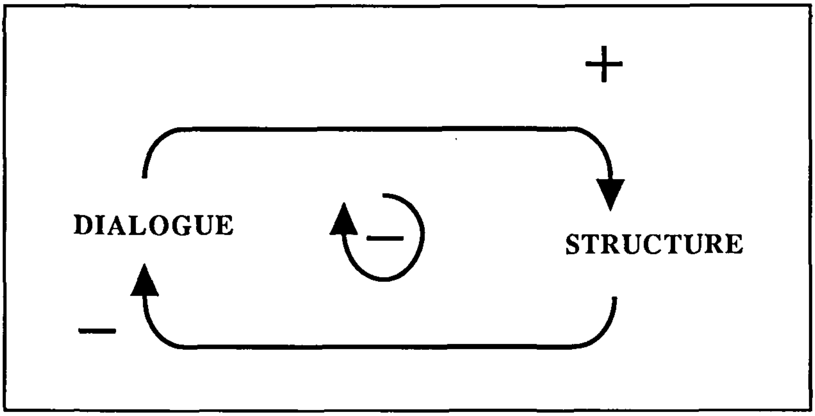

Figure 1. Causal Loop Diagram of Transactional Distance

System Dynamics

System dynamics is a technique for translating intuitive models into causal loop diagrams in which the effect of one system component on other functions is clearly illustrated by positive or negative feedback loops (Roberts et al. 1983). Based on these feedback—or causal—loops, flow diagrams are developed to illustrate each system function as a level or a rate of performance. The technique provides for translating the flow diagram into a set of more formal mathematical equations with STELLA, a simulation software program (High Performance Systems 1992). System dynamics allows objective observation of each system function in terms of its present level of performance and the rate at which this level decreases or increases through time. STELLA is capable of predicting and plotting the performance of each system function and the system as a whole in specific future time intervals.

The use of system dynamics in education dates back to 1961, when J. W. Forrester suggested that this technique (then known as Industrial Dynamics) be used to "integrate" management education (cited in Gould-Kreutzer 1993). More recently, Coldeway (1988) suggested the use of system modeling in distance education contexts to study several interrelated variables such as instructional content, technological delivery system, and policies related to course completion and the timing of course events. Also, based on Hawkridge and Robinson's (1982) analysis of international distance education organizations, Saba and Twitchell (1988/89) developed a system dynamics model that simulated the relationship of available resources, student population and attrition, management, instructional development, production of instructional materials, and dissemination.

Distance education is a complex concept; its study requires a methodology that can accommodate data collected on several variables as well as the analysis of their interrelationship over time. A dynamic systems approach to conducting this study was selected because, by definition, a system is "a collection of interacting elements that function together for some purpose" (Roberts et al. 1983, 5). Furthermore, distance education is not an isolated phenomenon; it is affected by the political, social, financial, and technological factors in its environment. System dynamics enables the determination of a boundary for the study of a system, as well as the enlargement of that boundary when it becomes necessary and desirable. For the purposes of this study, the system boundary was set to include only a few variables, which will be discussed later in detail. In future studies, this boundary will need to be enlarged to include other factors, as well.

System dynamics also provides for the study of interrelated variables over a period of time. The variables of transactional distance, dialogue, and structure are not static: they change over time depending on the course of interaction between an instructor and a learner. System dynamics not only includes past and present time as crucial elements, but also allows the study of interrelated variables as they are projected to change in *future* intervals. In conducting this study, system dynamics was used 1) to further expand the conceptualization of the system model suggested in 1988 by including additional relevant variables such as learner control and instructor control, and 2) to simulate the relationship between the key variables.

Roberts et al. (1983) suggest building a system dynamics model in six phases:

1. **Problem definition**, in which the boundaries of the problem are delineated
2. **System conceptualization**, in which relationships among variables are established
3. **Model representation and refinement**, in which computer codes are written and tested

4. **Model behavior**, in which behavior of the model is simulated over time
5. **Model evaluation**, in which the model's quality and validity are tested in trial runs
6. **Policy analysis and model use**, in which the model is used to test alternate policies

Five of these phases were used in developing the model in this study. The last phase was not included because this was a first attempt to expand the model beyond the conceptual analysis proposed in the 1988 study; deriving prescriptive "policies" seemed premature at this time.

Discourse Analysis

Discourse analysis is a technique for coding speech acts based on specific categories, or "phenomena" (Beach 1990), for understanding the "coherence and sequential organization" (Levinson 1983) of natural conversation. Discourse analysis was used in this study 1) to define four of the key variables in the study (active, passive, direct, indirect) and 2) to measure the rate and determine the level of all variables included in the study.

A review of theoretical literature (Anderson and Meyer 1988; Moore 1989; Harasim 1990; Juler 1990; Keegan 1990b; Shale 1990) led to consideration of a speech act as a unit for measuring key variables in the study. The review showed that social construction of meaning through discourse was of theoretical significance for understanding interactions in teaching and learning (Anderson and Meyer 1988). For example, the emerging constructivist theory of learning clearly indicates that meaning, in part, is constructed as the result of social interaction. Discourse analysis has been used for exploring communication in classroom interaction as well as in on-line, computer-based systems of teaching and learning. Black et al. (1983), for example, compared learner-instructor interaction in a face-to-face classroom situation with interaction on an asynchronous computer-based electronic message system. Based on the review of literature, discourse analysis seemed to be an appropriate way to measure system variables in this study.

There are several models of discourse analysis. One model is purely inductive: it provides no a priori categories for data analysis. The analyst considers each speech act as a new "phenomenon" to see if different patterns emerge throughout the course of the conversation. An alternative, theory-driven model provides for categories prior to data analysis. Because the system model for the research reported here was based on specific predetermined categories gleaned from the relevant literature, the latter model was selected for analysis of data.

The two approaches to discourse analysis are complementary rather than mutually exclusive. As integrated systems are adopted for distance education purposes in the future, it may be useful to analyze the dialogue between the instructor and the learner with a purely inductive approach to see if new and previously undetected categories emerge. For example, during the present study *communication maintenance* emerged as a subcategory when procedures for communicating through the integrated voice, video, and data system became a recurring subject of conversation between the instructor and the learners. A new subcategory was created to accommodate this type of data.

Defining Relevant Variables and Expanding the Distance Education Model

A series of pilot projects (Black 1988; Linstrum 1988, 1989; Bober 1990; Cox 1991) related to classroom interaction were reviewed and their relevance to the present study was determined. Also reviewed was Amidon and Flanders' (1967) model of classroom interaction analysis in which "teacher talk" was analyzed in terms of "direct influence" and "indirect influence." These categories, in turn, were analyzed in terms of other speech acts such as "accepts feeling" and "asks questions" for indirect influence and "lecturing" and "giving direction" for direct influence. In this early model, "student talk" was divided into the two categories of "response" and "initiation."

A major task in conceptualizing system models is determining which of the system components are levels, and which are rates. To expand the model and develop a flow diagram, the instructor's direct and indirect speech acts were viewed as analogous to the learner being active or passive, respectively. The resulting flow diagram includes three levels: 1) *transactional distance*, 2) *learner control*, and 3) *instructor control*. *Transactional distance* is conceived to be a function of the rates of *structure* and *dialogue; learner control* as a function of *active* and *passive*; and *instructor control* as a function of *direct* and *indirect*.

The variables, or system components, (see Figure 2) were defined as follows:

- *dialogue* is "the extent to which, in any educational program, learner and educator are able to respond to each other" (Moore 1983, 171). In other words, it is the extent of verbal interaction between the educator and the learner.
- *structure* is "a measure of an educational programme's responsiveness to learners' individual needs" (Moore 1983, 171) or the extent to which pace, sequence, feedback, and content are organized.
- *transactional distance* is a function of the variance in dialogue and structure as they relate to each other; therefore, "distance" in education is not determined by geographic proximity, but by the level and rate of dialogue and structure (Moore 1983; Saba 1988).
- *learner control* is a dynamic variable changed by the dialogue (discourse) between learner and instructor and continuously influencing (altering) the overall *dialogue* of a telelesson in terms of objectives, feedback, pace, sequence, content, etc. (Garrison and Baynton 1989; Shearer 1991).
- *active* indicates speech acts by the learner that show involvement in the instructional transaction: providing information, requesting clarification and elaboration, asking questions, providing feedback, and responding to the instructor's directives.
- *passive* indicates speech acts in which the learner responds by a simple yes or no, or the absence of speech acts for long periods.
- *instructor control* is a dynamic variable changed by the interaction between the instructor and learner and continuously influencing (altering) the structure of a telelesson in terms of objectives, feedback, pace, sequence, content, etc.
- *direct* indicates the instructor's expository speech acts that provide guidance, information, and feedback; lead the learner by asking questions; and respond to the learner by informative comments.
- *indirect* indicates the instructor's inquisitive speech acts that request clarification and elaboration from the learner, ask questions for the purpose of clarification, respond to the learner's inquiries, and provide supportive and corrective feedback.

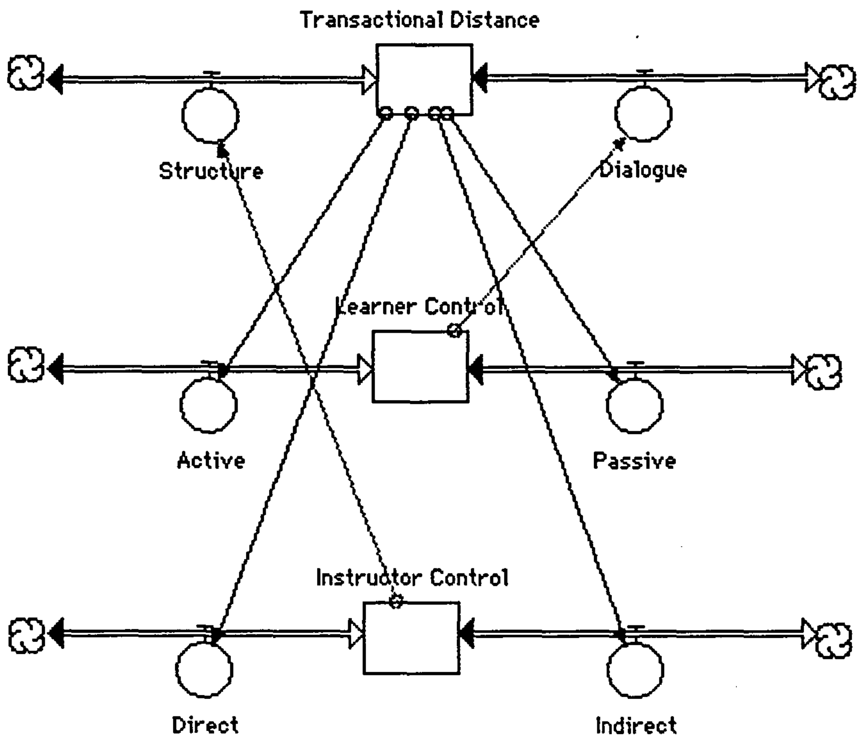

Figure 2. Expanded Flow Diagram of Transactional Distance

The flow diagram in Figure 2 also shows the relationships of these system variables. For example, *transactional distance* was conceptualized as a level, with *structure* and *dialogue* (both conceptualized as rates) increasing or decreasing it. *Learner control* and *instructor control* were also conceptualized as levels. In the former case, *active* is a rate, which was hypothesized to increase the level of *learner control* and is represented as a biflow. In other words, if the rate of *active* is high, it will increase the level of *learner control*, and if the rate of *active* is low, it will decrease the level of *learner control*; therefore, this relationship is represented as having the potential to flow in either direction. *Passive*, a rate that was hypothesized to decrease *learner control*, is also represented as a biflow. In other words, when *passive* is high, it will decrease the level of *learner control*; when it is low, it will increase control. Similarly, *direct* and *indirect* may flow in or out of *instructor control,* thereby adjusting its level. The word flow is used here as a metaphor to represent a mathematical relationship between two or more variables.

The flow diagram also shows direct influence from the level of *instructor control* to the rate of *structure*, and from the level of *learner control* to the rate of *dialogue*. It was assumed that an increase in the level of *instructor control* would increase the rate of *structure*, and an increase in the level of *learner control* would increase the rate of *dialogue*. Also, the level of *transactional distance* is shown to influence *passive, active, direct*, and *indirect*. It was further hypothesized that as the level of *transactional distance* increased, it would influence the rates of *passive* and *direct* positively and the rates of *active* and *indirect* negatively. The "clouds" at the outer limits of each level depicted in Figure 2 represent "infinite sources or sinks" for flows (High Performance Systems 1992, 60). The learner, for example, is a source of theoretically unlimited activeness.

These system components were determined to be adequate for the present study, which should be considered as an initial attempt to empirically investigate a dynamic model of distance education. In future studies, this diagram should be expanded to include other relevant components. For example, the activity or passivity of the learner and the directness or indirectness of the instructor may be a function of the course content or of the learner's prior experience. Some course content, such as factual information or procedures, may require direct instruction, which in turn will increase the rate of structure. Also, learners with prior knowledge of the content may be more active in asking questions and providing information, which will increase the rate of dialogue. Course content and learner experience, however, were treated as constants in this study.

Developing a Prototype

The third phase in developing a system dynamics model consists of formalizing the relationship among the system components in mathematical equations, which are also used as computer codes for simulating the model. In dynamic systems, variables are defined by equations to indicate their interrelationship. Interrelation of equations determines the values of variables (system components) at any point in time. In dynamic systems, variables are depicted over a period of time. System dynamics equations are basically of four kinds:

- Level equations
- Rate equations
- Auxiliaries
- Constants

According to Roberts (1983, 234), "[t]he value of a level at the present time *must* equal its value one time interval earlier, plus whatever flowed into the level over the time interval (minus whatever flowed out)." For example, in this study it was determined that *transactional distance* is a level which at each time interval is determined by its value one time interval before plus the value of *structure* minus the value of *dialogue* in that time interval. Another example, *instructor control*, was conceptualized as a level with a value at each time interval determined by the rate of *direct* minus *indirect*. Following is the equation for *instructor control*:

Instructor_Control(t) = Instructor_Control(t-dt) + (Direct - Indirect) * dt

In this equation "dt" represents delta time, or the length of the time interval.

Instructor control is a function of direct, which is shown as a rate in the following equation:

Direct=(30-(Content_Factor_+Experience_Factor_)) – (Transactional_Distance *.01)

The above equation indicates that the rate of *direct* is a function of the *content* of the lesson plus the *experience* of the learner minus a fraction of *transactional distance*. The fraction is to adjust the value of *transactional distance* to a factor between 1 and 10.

Flowing in or out of instructor control is *indirect*, which is a function of the lesson content plus the learner's *experience* plus a fraction of *transactional distance*:

Indirect = (30-(Content_Factor_+Experience_Factor_)) + (Transactional_Distance *.01)

Other system components were formalized in the same way. *Learner control*, for example, was conceptualized as a level in the following equation:

Learner_Control(t) = Learner_Control(t-dt) + (Active - Passive) * dt

The level of *learner control* was adjusted by the rate of *active* and *passive* in the following two equations:

Active = (Experience_Factor_+Content_Factor_) +
(Transactional_Distance *.01)

Passive = (Experience_Factor_+Content Factor_) -
(Transactional_Distance *.01)

Transactional distance was conceived as a level that is a function of *dialogue* and *structure*:

Transactional_Distance(t) = Transactional_Distance(t - dt) +
(Structure - Dialogue) * dt

(Structure = Instructor_Control; Dialogue = Learner_Control)

For the purpose of this study, *course content* and *learner experience* were set at a constant:

Content_Factor_ = Course_Content
Course_Content = 5
Experience_Factor_= Learner_Experience
Learner_Experience = 5

Data for these variables were not collected; however, it is essential that these variables be included in future studies.

Several runs were made to test the equations, "debug" the formulae, and observe whether the model behaved according to the assumptions made in the causal loop diagram and the flow diagram. Results of the final test run are presented in Figure 3.

The plot shows that there was a dynamic relationship between structure and dialogue in the hypothetical scenario. Over a period of time, as dialogue increased, transactional distance and structure decreased, and as structure increased, transactional distance also increased; dialogue, however, decreased.

Verifying the Model

To verify the model, the researchers proposed two hypotheses: 1) When *dialogue* increases, *structure* and *transactional distance* decrease; and 2) When *structure* increases, *transactional distance* also increases, but *dialogue* decreases.

To test the hypothesis, a telelesson on the subject of culture was designed. The instructor and the learner (N=30, with each learner interacting, one at a time, with the same instructor) communicated on a

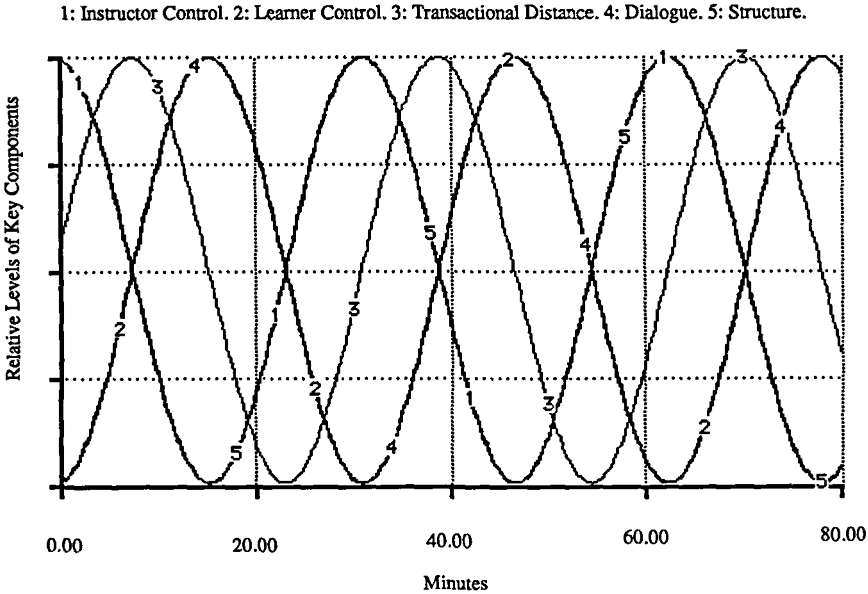

Figure 3. Plot of the Final Test Run of the Model

Note: Scales for the relative levels are excluded because they are different for each variable. The software automatically adjusts scale size in order to provide a comparative frame of reference.

prototype integrated data, voice, and video workstation. The prototype workstation was designed in an earlier study and refined during the past three years (Saba and Twitchell 1988/89). Participants, selected from a pool of graduate students, worked individually with the instructor. Although students and instructors worked from different locations, they could see each other via a closed-loop video circuit and talk to each other via an ordinary telephone. "Timbuktu" software was used to provide screen sharing capability between the learner and the instructor, both of whom used Macintosh computers connected to a local area network. The computer-based portion of the instructional content for the telelesson was produced in HyperCard.

Instructional transaction between the instructor and learner was videotaped on three recorders. All three recorders recorded the voices of the instructor and the learner as the telelesson progressed. One recorder also recorded the image of the instructor, the second recorded the image of the learner, and the third recorded the instructor's computer screen. Content of transactions was classified into ten main categories and twenty subcategories of speech acts to determine the rate of the variables *direct* and *indirect*. Content was classified into nine main categories and nineteen subcategories to determine the rate of the variables *active* and *passive*. (See Appendix for instructor and learner discourse analysis forms.)

Results of the Study

Measures of the variables provided the data for simulating the dynamic model. Initial values and the scale of the model were adjusted to reflect the values and scale of the data collected. Simulation results for five of the participants (shown in Figures 4, 5, 6, 7, and 8, respectively), were selected for discussion here.

As the plots of the first three sample runs show, data supported both hypotheses of the study (see Figures 4, 5, and 6). A dynamic relationship

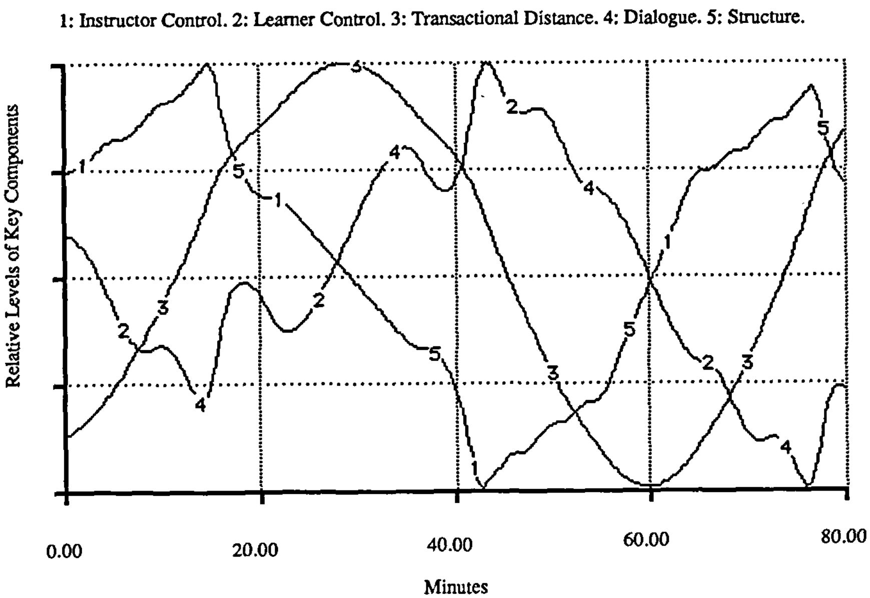

Figure 4. Plot of the Run for One Participant

between *structure* and *dialogue* was observed. In the thirty minute period during which the simulation based on collected data was run, *structure* decreased as *dialogue* increased. Also, *transactional distance* was maximized when *dialogue* was minimized and *structure* was maximized. In another words, when speech acts related to the learner's *active* responses increased during the course of the interaction between the instructor and the learner, *dialogue* also increased. Additionally, when speech acts indicating *direct* responses by the instructor increased, *structure,* as well as *transactional distance,* increased. Had the data indicated otherwise, the hypotheses of the study would not have been supported. For example, if the curve indicating *learner control* had increased with increasing *transactional distance,* or if the curve indicating *dialogue* had increased with increasing *structure,* then the results would not have confirmed the hypotheses. Further support for the hypotheses was provided when the model ran a projection of each variable into the future: the plots remained consistent beyond the initial thirty minutes of actual interaction.

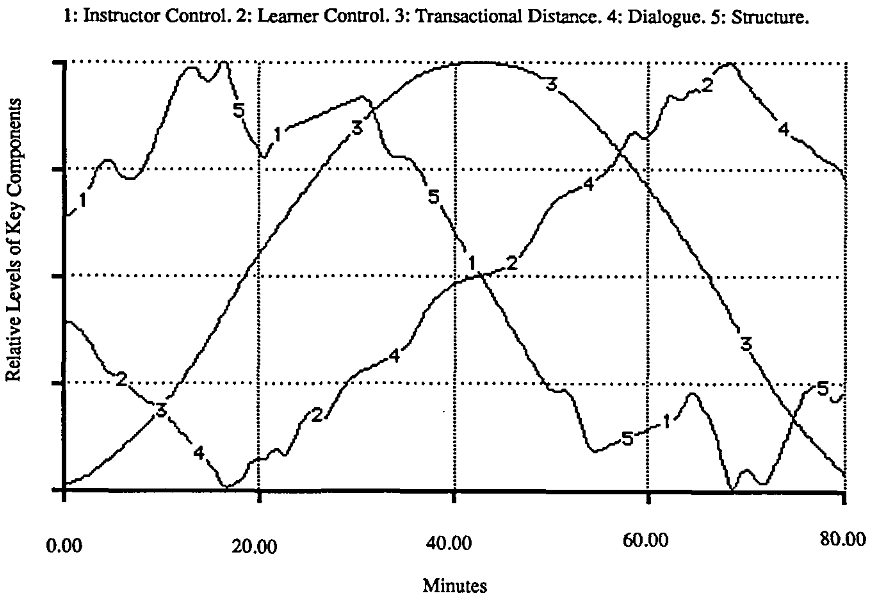

Figure 5. Plot of the Run for a Second Participant

In the first three plots (see Figures 4, 5, and 6), each learner's initial value for dialogue is different, and the data points for the plots are different; the general pattern of the curves are the same, however. When sufficient interaction between the instructor and the learner occurs, the model is upheld and both hypotheses of the study are confirmed. Each of these plots indicates an inverse dynamic relationship between *instructor control* and *learner control,* as well as between *dialogue* and *structure.* Also, *learner control* and *dialogue* are shown to be in phase.

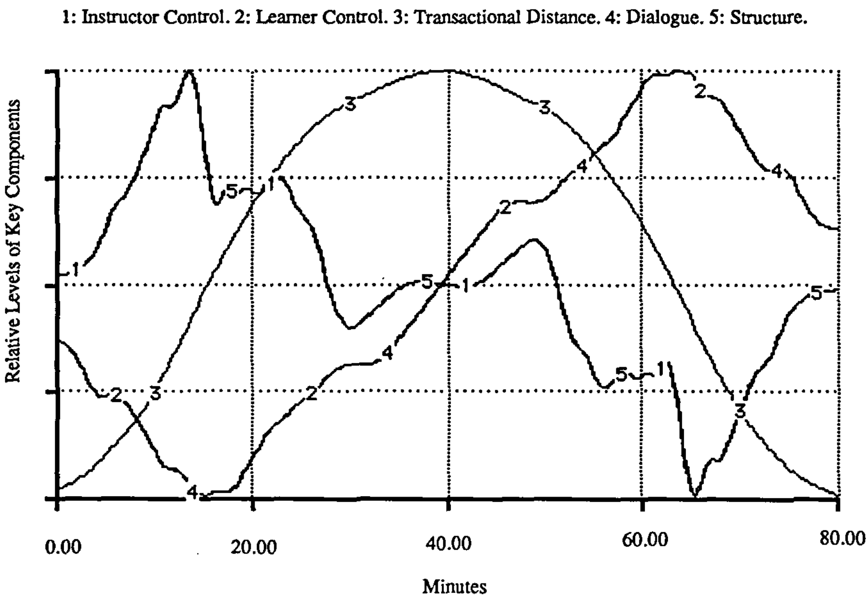

Figure 6. Plot of the Run for a Third Participant

Dynamic systems, however, are very sensitive to initial values. When interaction between the learner and the instructor started at a low rate and did not significantly increase within the thirty minutes of the telelesson, the plot showed a different result (see Figure 7). In the run for the fourth participant, *transactional distance* began to rise steadily from the outset and kept rising during the simulation. In this case, the simulation was run beyond the eighty minutes (the length for other runs) to see if the behavior of the variables showed any change. As evident in Figure 7, *transactional distance* increased so dramatically that the behaviors of all the other variables was not congruent with the test run of the model.

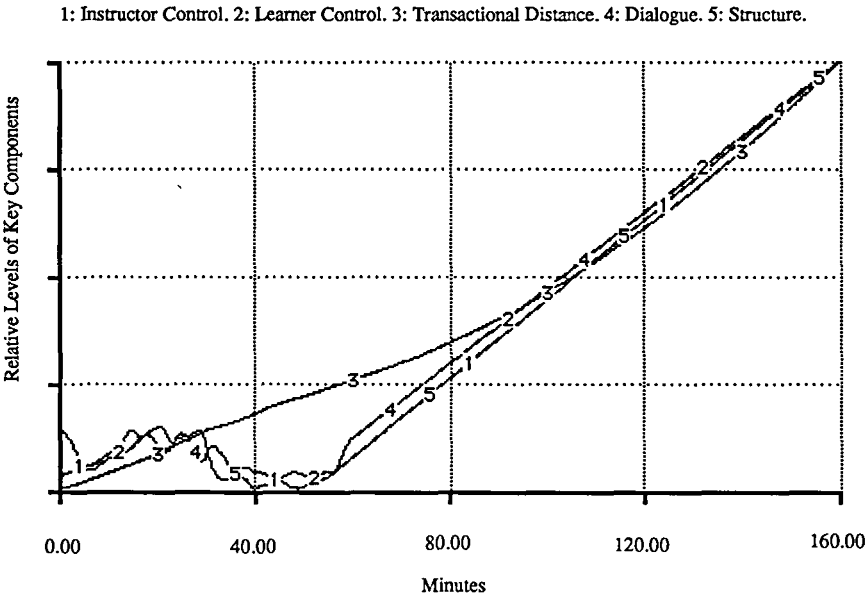

Figure 7. Plot of the Run for a Fourth Participant

This indicated the importance of a minimum amount of interaction to keep the model behaving in a way established in the test run. Determining this amount, however, will depend on further investigation. In Figure 8, for example, initial values of *dialogue* and *learner control* were higher than those of *structure* and *instructor control.* (Note that in Figures 4, 5, and 6, the initial values of *dialogue* and *learner control* were lower than those of *instructor control* and *structure.*) In this case, the general pattern of interaction during the first thirty minutes was similar to that of the participants represented in Figures 4, 5, and 6. However, simulation of the interaction after the thirtieth minute showed a dramatic decrease in *structure* and *instructor control*: both of those values dropped to zero, while *dialogue* and *learner control* remained high. Further review of the discourse analysis chart indicated that, in this particular case, the instructional transaction was dominated by the learner during the course of the telelesson.

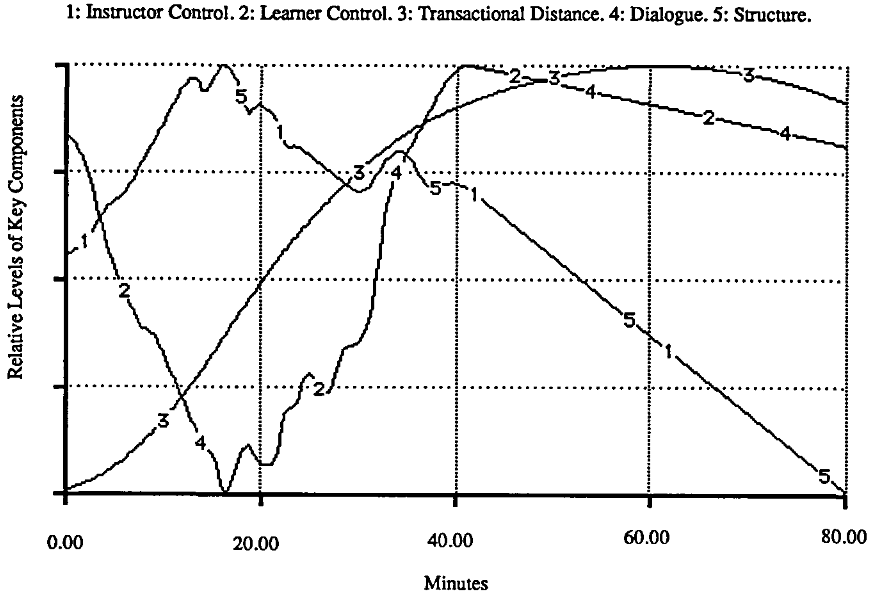

Figure 8. Plot of a Run for a Fifth Participant

To see the degree to which the key variables (*direct, indirect, active,* and *passive*) had a positive or a negative correlation, a Pearson correlation coefficient analysis was administered on the results of the five participants reported in this study. Table 1 shows the result of this analysis.

As Table 1 shows, a strong negative correlation was observed between *direct* instructor behavior and *active* learner behavior. Also, a positive correlation was observed between *indirect* instructor behavior and *active* learner behavior. Low correlation existed between *direct-indirect* and *indirect-passive.* This result is probably due to the low number of categories on the discourse analysis instrument relating to indirect instructor behavior and passive learner behavior. These results reinforced the comments made by the participants during the exit interview.

Table 1. Correlation Analysis of Key Variables

S	OR	D-I	R	D-A	R	D-P	R	I-A	R	I-P	R	A-P	R
1	9	- 0.5533	1	- 0.3529	4	0.6277	1	0.5843	1	- 0.3745	1	- 0.4419	1
2	15	- 0.3273	2	- 0.4542	3	0.5275	2	0.4334	2	- 0.0279	3	- 0.3561	3
3	23	0.0789	5	- 0.3116	5	0.4209	3	0.356	3	- 0.2486	2	- 0.1985	5
4	21	- 0.2521	3	- 0.6031	1	0.3431	4	0.3454	4	0.2902	5	- 0.3048	4
5	22	- 0.1635	4	- 0.5087	2	0.1628	5	0.2625	5	0.07552	4	- 0.3862	2
1-5		- 0.1911		- 0.4761		0.59219		0.53081		- 0.0636		- 0.6129	

S= Subject; OR = Overall Rank; D-I = Direct-Indirect; D-A = Direct-Active; D-P = Direct-Passive; I-A = Indirect-Active; I-P = Indirect-Passive; A-P = Active-Passive; R = Statistical Rank.

Learners' Perceptions

After learners completed the telelessons, a different set of data, relating to their perceptions of the experience, was collected. In an interview with one of the co-authors, learners were asked to respond to eleven questions focusing on their perceptions of the technical capability of the system, the instructor's management of the telelesson, and their willingness to recommend participation in the study to others. The exit questionnaire was analyzed by gender, degree level, and prior distance education experience. Of the thirty subjects who participated in the study, sixteen were men and fourteen were women. All but one of the learners were currently enrolled in the Master of Arts in Education program with a concentration in Educational Technology; ten of the subjects indicated that they had previous experience with distance education course work.

All students who participated in the study indicated that they generally liked the telelesson. Thirteen students also indicated that, given the choice of taking a distance education class or a traditional class, they would choose to take the distance education course. Many elaborated, stating that the one-on-one nature of the lesson would lead them to choose a distance education course that used the desktop workstation. The other seventeen students indicated that, although they liked the telelesson experience, they would prefer a classroom environment. Additional comments made by these students indicated that their main reason for choosing the classroom environment over a distant course was the opportunity for interaction with other class members. Other themes emerged in students' comments:

- The experience was uncomfortable at first, but became relaxed as the lesson progressed.
- The instructor made the experience very positive.
- The instructor had a positive attitude and style.
- The ability to see the instructor was an important aspect of the experience.

Of the thirty students who participated in the study, all but three indicated that they believed their participation in the telelesson was *active*. However, there appeared to be confusion over the definitions of *direct* and *indirect* in terms of instructor style: eleven students classified the instructor's style as *direct*, yet classified themselves as *active*.

Discussion and Conclusions

This project was designed to develop a method to empirically verify key variables and their interrelationships in a dynamic model of distance education. In the hypothetical model, *transactional distance* decreases when *dialogue* increases and *structure* decreases; when *structure* increases *transactional distance* also increases, but *dialogue* decreases.

Although each learner's data was different, there was a distinct and similar pattern among the simulated results. The general pattern shown in Figures 4, 5, and 6 indicates that *transactional distance* varied according to the rate of *dialogue* and *structure*. An increase in the level of *learner control* increased the rate of *dialogue*, which in turn decreased the level of *transactional distance*; an increase in the level of *instructor control* increased the rate of *structure*, which in turn increased the level of *transactional distance*. The levels of *learner control* and *instructor control* varied according to the rates of *active* and *passive* speech acts, as well as the rates of *direct* and *indirect* speech acts. These results verified system components in the flow diagram in Figure 2, as well as the interrelationships among the variables in the model.

A tentative conclusion to be drawn from this study is that *transactional distance* varies by the rate of *dialogue* and *structure*. This conclusion, if further verified, has important ramifications for the field of distance education and for its relationship to main-stream education. If distance is truly a function of the responsiveness of an educational program to its students, then the quality and amount of transaction between the learner and the instructor, regardless of their geographic proximity, becomes of utmost importance. The desired instructional strategy becomes maintaining a proper balance between dialogue and structure.

This study also demonstrated the use of a theory-driven model of discourse analysis to measure key variables: the extent to which learners are *active* and *passive* and instructors are *direct* and *indirect.* Also, discourse analysis yielded the type of data required for running a simulation of a system dynamics model.

System dynamics modeling has been used for studying industrial, biological, ecological, and social systems. This study demonstrated that it also can be used successfully for modeling systems designed to verify key concepts in a distance education theory.

Future Research

This study was limited to measuring nine key variables in a dynamic model of distance education. In future studies, additional variables should be included to allow the model to more closely reflect the myriad variables involved in a telelesson.

For example, in integrated systems, dialogue and text are transmitted by the telephone and the computer screens; additionally, body language is transmitted by the video system. The video images of the instructor and the student are rich with facial expressions, body position, and body movement. Coding systems should be included in future studies to include such transactions in the data. Furthermore, units of measurement should be selected and examined for all variables.

As multipoint switching becomes available in integrated desktop workstations, the study should be expanded to include instructor-learner transaction in which more than one learner is involved, as well as learner-learner and learner-subject interactions. In these future steps, rigorous means for further examining the dynamics of instructional transaction in integrated distance education systems must be developed. The emergence of integrated workstations and the addition of video and audio to the Internet will provide a rich environment for continuing this line of inquiry.

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Appendix

Learner Discourse Analysis Form

Minutes	1	2	3	...	30
Active					
Requests					
Claritive					
Elaborative					
Information					
Declaration					
Concept					
Example					
Procedure					
Principle					
Elaboration					
Clarification					
Questions					
Inquisitive					
Claritive					
Directive					
Feedback					
Supportive					
Directive					
Corrective					
Pace Pause					
Passive					
Response to					
Guidance					
Request					
Direction					
Information					
Comm. Maintain. Pause					
Response (Affir./Neg.)					
Pause					

Instructor Discourse Analysis Form

Minutes	1	2	3	...	30
Direct					
Guidance					
Advance Organizer					
Comm. Maintenance					
Directions					
Requests					
Information					
Declaration					
Concept					
Example					
Procedure					
Principle					
Elaboration					
Clarification					
Questions					
Inquisitive					
Claritive					
Directive					
Response					
Supportive					
Directive					
Corrective					
Pace Pause					
Indirect					
Guidance					
Questions					
Inquisitive					
Clarative					
Elaborative					
Response					
Inquisitive					
Supportive					