Interactivity Demystified: A Structural Definition for Distance Education and Intelligent CBT

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Interactivity

"Interactive" and "interactivity" are some of the most commonly used terms in instruction. For example, we are often told that multimedia (among other emerging technologies) is superior to "traditional" instruction, often because it is "interactive." However, the term interactivity is a loosely defined term that, according to Rose (1999), seems to deconstruct itself when closely examined. Her insightful and provocative article contends that the term is filled with inconsistencies. In his keynote address at AACE, Thomas Reeves (1999) seemed to agree. He claimed that we do not have a very good definition of interactivity in instruction, and that "teacher-in-a box" has been the prevailing approach to the design of mediated instruction.

Interactivity in Distance Education

Distance education is the practical subset of education that deals with instruction in which distance and time are the criterial attributes; that is, student and teacher (and other students) are separated by distance and/or time. Interactivity in instruction under these time and distance constraints is a variable that is likely to be critical to the success of distance education. Many leaders in distance education echo Rose's and Reeves' concerns more broadly: not only is 'interactivity' poorly defined but, in general, distance education suffers from a lack of theory. Moore (1989) agrees that the term 'interaction' has been misused and "carries so many meanings as to be almost useless unless specific submeanings can be defined and generally agreed upon." The Institute for Higher Education Policy's recent review on distance education (1999) similarly cited the lack of a conceptual or theoretical framework as a major shortcoming in the study of distance education. The general lack of theory in distance education of has been cited by numerous researchers in AECT & RISE's recent update of the distance education literature (Hanson, Maushak, Schlosser, Anderson, Sorenson, and Simonson, 1997).

Computer-Based Interaction

In the future, we will have more opportunities to learn *through* computers, *with* computers, and *from* computers. Generally, the focus of distance education has been on using the computer primarily as a communication tool (learning *through* computers). The "computer-as-mindtool" approach (Jonassen & Reeves, 1996) suggests that working with the computer, in an authentic task, acts as a stimulus for learning (learning *with* computers). Despite criticism of teacher-in-the-box CBT, efforts to improve the human-ness and adaptivity of our interactions with computers will likely improve our ability to learn *from* them.

We have only begun to gain the critical mass of interface technologies needed to make the computer an intelligent partner in instruction. Work in the development of *intelligent agents* attempts to produce software that acts as an intelligent assistant (Murch & Johnson, 1999). Some intelligent agents feature a conversational component that has a human visage and displays facial gestures--in essence displaying personality or character (Maes, 1997; Acovelli & Gamble, 1997). The work of Reeves and Nass (1996) shows that humans use social rules as they interact with computers. As we combine these capabilities with natural language understanding and the ability to process "spoken speech," the computer approaches the role of partner in a conversation rather than a questioner or simple conditional decision maker.

These streams converge on the need for a definition of interactivity, both in distance learning *through* computers as communication tools and in intelligent instructional systems where we learn *from* the computer tutor/teacher. The intent of this article is to provide a structural definition of interactivity, with the goal of describing and delimiting a broad and general process. This structure suggests additional variables that could likely be valuable in understanding interaction in instruction.

A Historical Analogy

A major contribution to the field of communication was Claude Shannon's communication model, first published in 1948. This paper became the nexus for an area of inquiry and study, commonly labeled *information theory* (Pierce, 1961). In creating a mathematical model of the communication process, Shannon concentrated on the structure of communication, and the properties of information itself, independent of the meaning of the communication. In essence, his ideas did not look at the *content* of communication, but rather examined some general truths about information and transmission. The information theory model has been valuable as a Rosetta stone for communication researchers in the areas of both human and machine communication. By forcing us to think about the structural aspects of communication, we have gained insight into both human and machine systems.

The Basics of Interactivity: A Definition

There are four major attributes to the concept of interactivity:

- Interactivity is a message loop;
- Instructional interactivity occurs from the learner's point of view and does not occur until a message loop *from* and *back to* the student has been completed;
- Instructional interactivity has two distinct classes of outputs: content learning and affective benefits;
- Messages in an interaction must be mutually coherent.

Each attribute will be examined in turn.

Interactivity is a message loop
Structurally, interactivity is a circuit of messages flowing from an originating entity to a target entity and then returning back to the originating entity. We shall refer to this as an *interactive loop*. *Entities* in an interactive loop can be students, instructors, computers, or other media capable of receiving and sending messages. For example, common interactive loop patterns might be: student to teacher to student, student1 to student2 to student1, or student to computer program to student. Similar to the way electrical current must make a complete circuit, an interactive loop only exists if a trail of messages can be traced from an originating entity to a secondary entity and back to the original. This completed loop is shown in Figure 1.

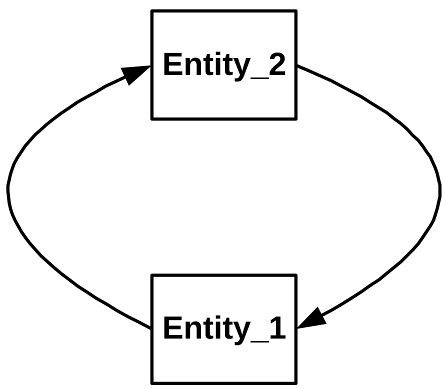

Figure 1. A completed message loop between two entities

Wiener (1954) noted this relatively powerful message cycle and used the term *cybernetics* to describe the loop. According to Wiener, communication and control in a cybernetics loop were essentially the same activity; an entity can control itself (or is controlled) by feedback messages from the environment. Wiener states, "Thus the theory of control in engineering, whether human or animal or mechanical, is a chapter in the theory of the messages." (pg. 17). 'Message' in an interactive loop refers not only to spoken messages but also to overt physical activities that are directly perceived by either entity.

Contemporary authors use a similar concept in the area of systems dynamic modeling. The *causal loop* or *feedback loop* in system dynamics is claimed to be central in understanding human, organizational, and machine behavior (Senge, 1990; Forrester, 1980). The causal loop represents the instrumental actions that one makes within a complex system, and their associated feedback chain. The notion of the causal loop concurs that control and communication both happen via messages passed between entities, forming a complete interactive loop. Additionally, Roberts and associates (Roberts, Anderson, Deal, Garet, & Shafer, 1983) assign a valence (a plus or minus sign that could represent a more exact multiplier) to the connections between entities.

Gavora and Hannafin (1994) describe the operation of interaction as consisting of a physical response and feedback based on the response, hence describing a loop. However, their definition also claims that "a physical response, by itself, is neither a necessary nor sufficient condition for interaction." It is not clear how one sends a message without overt behavior of some form. Therefore, by our definition, a physical response *is* a necessary condition of interaction. Parker (1999) reviews several definitions of interaction and does not attempt a summary of definitions, but points out the loop-like quality that is common across several definitions. Daniels and Marquis (1983) support the loop structure in their definition of interactivity. Schaffer & Hannafin (1986) describe a "fully interactive" research treatment consisting of embedded questions and system feedback to student responses, again supporting the completed loop notion.

From a student perspective
Our definition contains an element that other definitions assume, but never explicitly state: interactivity in instruction must occur from the student's point of view.
As designers of computer tutors, or as distance educators, we often are egocentric in following the loop-- leading us to describe material as interactive when it is not.

Compare the following communications from two points of view: the teacher and the student. From a teacher's point of view, a complete interactive loop has happened when the teacher communicates a message to the student, and the student responds back to the teacher (see figure 2). However from a student point of view the loop is only half completed; the student has sent a message to the teacher, but often there is no response in return. In this case we have an open circuit (see figure 3).

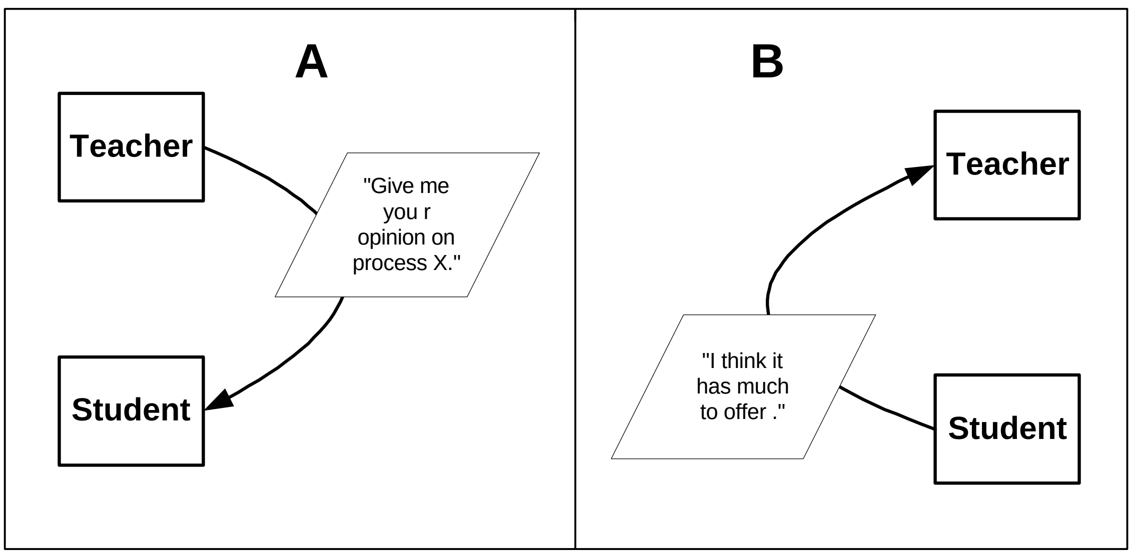

Figure 2: Two steps in a completed loop as (a) the teacher asks a question and (b) the student responds. The loop is complete from the *teacher's* perspective.

If we look at interactivity from the student perspective, we realize that many alleged interactive lessons and devices are not interactive at all. For example, a teacher may ask a student for a response, and receive the response from the student but fail to provide feedback, thus failing to complete the student's interactive loop. From the student perspective the student response is sent "into the vapor" with no sense of transmission received, transmission accepted, transmission understood, or transmission lost.

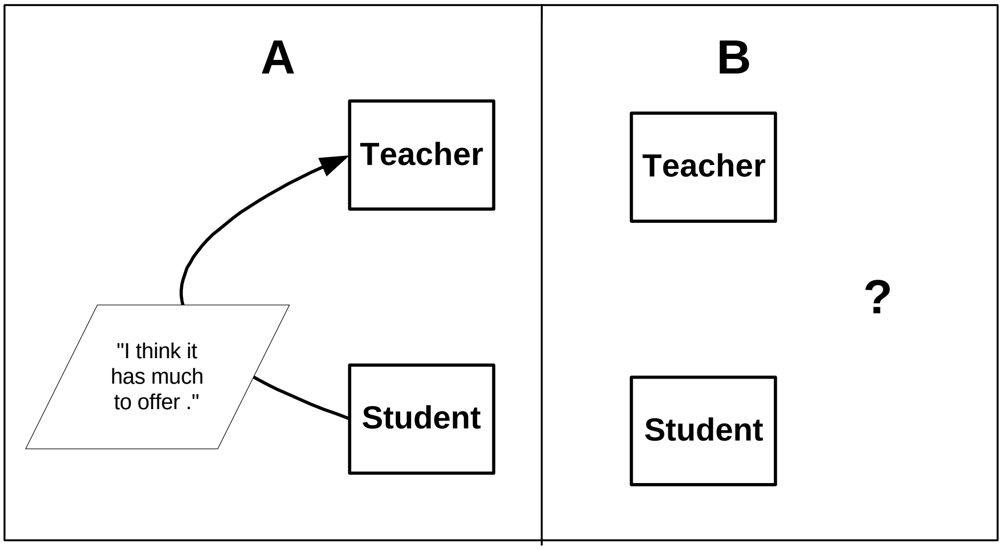

Figure 3: The same interaction from the *student* perspective. The loop is not complete.

Learning happens solely within the individual learner. Although instruction may provide stimuli (such as a question or a controversial statement), the messages of interest flow from the student (as he or she recalls a fact, disagrees with the statement, or expresses confusion with the transmission) and back to the student in a student-centered loop.

An interesting issue regarding the perception of interactivity occurs with branching computer based training in which the instructional program selects different paths based upon student responses. Such an interactive system may not *appear* to be interactive to the student; because a student does not see the alternative branches, the program may appear to be *linear* to the student. Even though the program is responding, the student may not sense that the system's displays are predicated on his or her message. Unless the student sees that he or she is skipping material, or being led to remedial material, the student may not actually perceive the computer's differential responses as interactive.

Moreover, the perennial straw man for passive teaching, the "classroom lecture," may actually be more interactive then we acknowledge. Obviously, the straight "transmission" lecture (with no pauses and with no acknowledgement of student presence) has little opportunity for interactivity. However most lectures that I have witnessed are not delivered to that extreme. Generally a classroom instructor in the process of lecturing expects and encourages students to interrupt with questions (or at minimum, *tolerates* them). The possibility for student to ask a question of (send message to) a teacher and receive a return message fulfills our definition of interactivity, in some cases better than so-called interactive technologies.

According to Zhang and Fulford (1994), a student's perception of interaction is not necessarily correlated with the actual amount of time in interaction. Zhang and Fulford studied a distance learning television classroom, where it was possible to measure the time of interaction. Interestingly, the students' perception of interactivity (in a rating scale) did not correlate with the actual clock time of interactions. This led the researchers to conclude that perceived interactivity is a psychological construct of each student. It is more likely that the interaction time as measured in their study was inflated by including messages that were not part of the student to teacher to student interaction. That is, their definition may have classified teacher-centered actions that we would not consider interactive by our emerging definition. Therefore, their variable of *perceived interaction* may actually be closer to our definition of interaction.

Apparently, student's perceive interactivity as a student-centered event; large amounts of classroom activity may not correlate with a single student's individual interactivity.

Effects of interactivity

Two distinct types of effects can occur through interactivity: (1) content learning and (2) affective benefits. *Content learning* is herein described as purposeful learning directed toward attaining an instructional goal. *Affective benefits* are described as emotions and values toward instructional artifacts that are dampened or amplified. Of the two, we find that content learning seems to be the better understood. A similar set of ideas were alternatively referred to as *instructional interactivity* and *social interactivity* by Gilbert and Moore (1998), although these terms seem to reflect the role of the interaction in the instructional process, rather than the effect of the interaction.

Content Learning

Piaget's work (1971), in which interaction with the environment is the basis for learning, is but one example of a learning theorist who explains the content learning effects of interactivity. Variations of behaviorism cite interaction with environment as *reciprocal determinism* that produces learned responses.

Content learning from a cognitive perspective can be accounted for using schema theory, which posits that knowledge is organized in knowledge structures called schemata. (Rummelhart, 1980; Anderson, 1985). Learning in this model is the process of adding knowledge to existing structures, slightly modifying the structures, or creating new structures. When new information enters the cognitive system, it is either placed into existing schema, (a process called *accretion*), or the schema are slightly modified (*tuning*), or else an entirely new schema is created (*restructuring*) in cases in which new information is discordant with existing information. This notion is similar to the work of Piaget who describes similar processes called *assimilation* and *accommodation* (Hergenhahn, 1988). Rieber (1994) provides a detailed explanation of the mechanisms by which content learning can take place according to schema theory.

Affective Benefits

The affective benefits of interactivity are less well understood. Interactions in an online classroom provide social presence and satisfaction in mediated situations (Vrasidas & McIsaac, 1999; Stevenson, Sander, & Naylor, 1996). Brophy (1999) claims that although recent research provides great insight into *expectancy* motivation (the type of motivation providing belief of success), we still have little insight into *value* motivation (the type of affective outcome in which a student begins to value the artifacts of the instructional process). It would appear that certain aspects of the affective domain are still little understood, such as the mechanisms by which a student learns to value subject matter, learns to respect a community of practice, or learns to value the overall institutions of learning.[1]

Mutual Coherence of Messages

A final attribute in our definition is the mutual coherence of messages. This term is used to describe the relationship between a message and its response. Thus far in our description of interactivity, we have focused on the routing of messages, and their general effects, but have said little about message content.

Within a student-centered interaction, there must be some relationship between an entity's message and the response back to that originating entity. Thus, the analysis of message content should not be made in isolation; the content of both going and returning messages must be

[1] This should not imply that interactivity is the sole cause of affective benefits. Many factors may cause affective change in learners.

considered if we are to make sense of the interaction. We use the term *mutual coherence* to label the shared meaning between both messages in an interaction. In the jargon of data communication, the actual text message that is passed between entities is referred to as the "payload." Therefore, we might alternatively define mutual coherence of messages as a sent payload and its response payload that both refer to the same topic.

It is easiest to recognize interactions with low mutual coherence. A dialogue with zero mutual coherence might be the following:

> Student: "I feel so lost in this course."
> Teacher: "Football is my favorite sport."

An interaction with very low mutual coherence might be:

> Student: "I feel so lost in this course."
> Teacher: "The final exam for the course is next week."

An interaction with high mutual coherence might be:

> Student: "I feel so lost in this course."
> Teacher: "People often feel lost in a distance course."

While it is difficult to specify the "meaning" of messages, we believe that the extent of the shared meaning between messages influences the perceived degree of interactivity. Most readers have experienced "conversations" with friends in which our statements are followed by unrelated responses having nothing to do with the topic at hand--almost as if the participants in the conversation are not listening to each other (which is probably what occurs). Most have also experienced the other end of the spectrum, where we have perceived almost a singularity of mind with another human being. In these cases the shared meaning between messages is high; therefore, the mutual coherence is high.

Mutual coherence does not address the relationship between the interaction and the goals of instruction. For example, two entities might have a very high mutually coherent interaction that is irrelevant to course goals. One might suspect that interactions that produce *affective benefits* are not always directly related to instruction, and in a *content learning* sense might be deemed irrelevant. However, we believe that these "irrelevant" interactions produce valuable outcomes to the degree that they influence affective benefits.

Definition Summary

At this point, we have provided the general structure of instructional interactivity, summarized in Table 1. The following sections provide additional detail regarding likely important variables in the process, derivable from the basic structural definition already provided. Some of the following concepts borrow heavily from data communication models, interpersonal communication models, and other equally eclectic literature.

Structural Definition of Interactivity
1. Interactivity is a message loop
2. Instructional interactivity occurs from the learner's point of view
3. Instructional interactivity has two outputs
a) content learning
b) affective benefits
4. Messages must be mutually coherent

Table 1. A summary of major elements of the structural model of interactivity

Additional Variables of Interest

There are four additional variables that arise through the structural study of interaction, illustrated in Figure 4. They are:

- Multiplex messages
- Message duration
- Information content
- Lag time of response

The intent is not to describe the exact law-like relationships between these variables, but rather to sketch the manner in which these variables are likely to be critical to the instructional process.

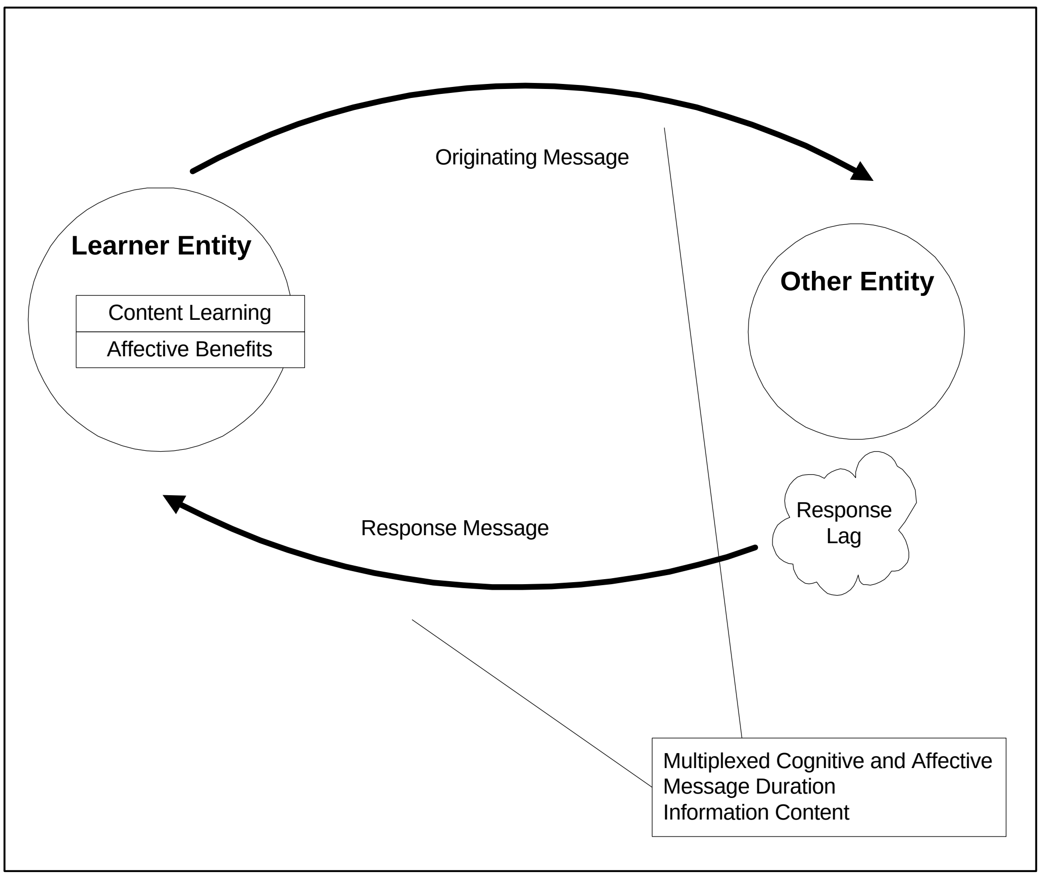

Figure 4. Additional variables that relate to the structural model

Multiplex messages

The mechanism by which messages carry information of a cognitive and affective nature is loosely comparable to the manner in which electrical signal components can be combined into an aggregate signal, referred to as *multiplexing*. In communication lines, there are several mechanisms by which a single line can transmit multiple messages simultaneously. At the receiving end, a Fourier analysis (or other appropriate method) is used to separate the components of the signal, such that each message is once again distinct. Our analogy is not meant to consider the exact mechanics of the human system, but merely to sketch a similar mechanism for conveying different types of messages with different types of *meaning* within the same signal. Instructional messages have the potential to carry information concerning both content and affect.

In communication theory, the nonverbal components of a message (such as tone of voice or speed of speech) are referred to as *paralanguage*. Paralanguage is a powerful mechanism for communicating affect. In distance learning, the term *emoticon* has developed to refer to the set of text symbols used to communicate *emphasis*, cynicism (grin), winks ; -), and other affective communicative acts. In spoken language we sometimes fail to notice the dual channel nature of the communication; in written words, paralanguage must be explicitly coded.

Purely affective messages (or nearly pure) are commonly sent between humans in face-to-face communication. The "steely glance" between husband and wife is a classic example of nonverbal communication that conveys displeasure. As noted earlier, in many instructional situations, such as distance learning, web-based training, or CBT purely affective messages do not "naturally" happen in the process. They must be explicitly considered or designed. Moreover, the lack of these affective messages may unintentionally signal lack of interest or lack of caring.

Feedback researchers have examined the inconsistency in behavioral theories of feedback that equate feedback as *primarily reinforcing* with feedback as *primarily informational* (Dempsey, Driscoll, & Swindell, 1993). While they use different terms, the idea that there is a motivational (affective) component that is separable from the informational (content learning) component is a similar idea. Although he does not supply a detailed theory or explanation for the terms, Berge (1999) similarly cites *task/content* interaction and *social* interaction as key variables in web-based learning.

Message Duration

Message duration refers to the length of each message in an interactive loop. This variable is operationalized simply as the elapsed time between start and finish of message. Although there are published practical guidelines for message duration (for example, Filipczak, 1996), we could find little in the distance education or instructional technology literature explaining this apparently simple variable.

We can emphasize the value of this variable by looking at the extreme cases. Consider a course that was extremely transmissive: a sixteen week series of videotapes sent to a student with no questions asked during that time. At the end of sixteen weeks, the student is required to write a paper that summarized the transmitted data. Upon receiving the student's paper, the teacher assigns a grade and writes "excellent paper." Mapping this extreme case study to our structural model of interactivity shows that such an exchange between teacher entity and student entity actually *meets* our definition of interactivity. However few of us would suggest that this discourse had been ideal. Why? The duration of the messages in the interaction are (in order) too long, too long, and too short. When we think of interactivity, it is expected that the messages will be of a moderate to short duration. The exact thresholds have not been established, and may be different depending on the situation.

At what point does an interaction turn into a series of monologues? There is likely to be an upper and lower range of message duration that defines what most would feel to be an appropriate degree of interaction. However, given the lack of available research in this area, we can we can only guess that there is an optimal message duration, or that there would be agreement as to what message length constitutes appropriate interactivity.

Amount of Information Content

The amount of information included in the message and the duration of the messages both contribute to mutual coherence. *Amount of information content* in this context refers to the amount of new information that is transmitted, independent of the length of the message. To explain this clearly, we must refer to Shannon's original concepts of *entropy* and *information.* Entropy (in information theory) relates to the amount of uncertainty regarding messages. A message that we are likely to be able to predict (low entropy) contains less information than a message that is largely unpredictable (higher entropy). As Pierce (1961) cleanly states it, "The more we know about what message the source will produce, the less uncertainty, the less the entropy, and the less the information." (pg 23).

From these principles, we might infer that confirmatory feedback messages contain more overlap in meaning. If both sides share similar structural knowledge (Jonassen, Beissner, & Yacci, 1993), then the message contains little uncertainty and hence little information. In essence, it is predictable. Instructionally, these situations occur when a student seeks feedback, and the student response is "correct." In such cases, confirmatory feedback messages should be succinct, because they contain no new information--in essence, they are almost completely redundant, once we have established that the student is correct. This idea coincides with Kulhavy and Wager's conclusion that feedback "primarily acts as a unit of information, and has its greatest effect when it follows an *incorrect* response" (1993; italics in original). This finding is consonant with Mory's in-depth review of feedback research (1996). With an incorrect response, the sender and responder do not share the same underlying structural knowledge, and therefore there is more uncertainty in the dialogue between them. We would conclude that there is greater information in the messages that follow an incorrect response, and that these high information responses would be perceived as highly interactive.

It should be noted that redundancy might provide value in instruction. Redundancy according to information theory is a useless component of the signal which conveys no intelligence (Pierce, 1961). Because information can be supplied at the receiver's end (in cases where the response is totally predictable), it need not be transmitted. However, students may have different degrees of confidence as they approach a task. In some cases, redundancy in instructional responses might serve to re-assure a learner, hence providing affective benefits more than content learning.

The information content and duration of messages are likely to be the major components of mutual coherence. That is, the way that messages "hang together" is likely to be a function of the amount of information contained in the message, the length of the message and its topic. However, as this section explained, the entropy of a response message (its predictability) is different depending upon whether the initiating message was correct or not.

Response Lag

Response lag refers to the delay between sending an initiating message and receiving a response message in an interactive loop. Response lag can be operationalized as latency between an entity's sending of a message and the eventual time in which the response message returns. In the case of synchronous learning, response lag is usually only a few seconds. For example, a student might ask a question and a teacher may momentarily pause to think of the answer, and then respond. In the distance learning situations that are synchronous in nature, such as interactive television, we would expect to find the same short response lag in many interactions. However, in an asynchronous environment, response lag is expected.

Adding to the confusion over this issue: in many forms of asynchronous learning, there is a storage medium that maintains messages until they can be read. Using computer networks to deliver text based e-mail (asynchronous communication) generally means that messages will be stored at each entity in the loop. While we might think that this storage medium effectively eliminates response lag as a variable, if we carefully analyze the interaction from the student view we find that not to be the case. Student entity A sends a message to teacher entity B. Teacher entity B may not read a message for several days. After reading the message, the teacher responds within minutes. To the teacher, the apparent response lag is nil; lag time has been effectively mediated by the storage medium. However, from the student point of view, there was a significant response lag; the student had to wait several days to get a response. The student's ability to re-read a copy of his or her original message can no doubt help to lessen the perceived response lag. However, it is likely to be disconcerting to the student to receive a response to a message sent weeks earlier. Often, original message intent is forgotten. Response lag from the student point of view would therefore appear to be an important variable.

Mory's review of delayed versus immediate feedback examines a variety of alternative explanations and research results concerning the benefits and weaknesses of delayed feedback (Mory, 1996). She concludes that except for unusual, experimental cases, there has been no general benefit for delaying feedback.

Patterns of Mutual Coherence

There are several attempts to classify the types of interactions that might occur, both in the classroom and in distance education settings (Offir & Lev, 1999). Henri (1992) conducted content analysis and determined five categories of interactions that are commonly found in distance learning: participative, social, interactive, cognitive, and metacognitive. Two of his categories, *cognitive* and *social*, are similar to our explanations below. A different set of interaction types was proposed by Gavora and Hannafin (1994) with a classification scheme that examined types of interactions. Moore's (1989) often-cited approach to classifying interactions involved the roles of the participants in interaction, including teacher-student, student-student, student-content. Rao & Dietrich (1996) use the general terms *simple interactions between teacher and student* and *complex interactions* as descriptors of activities within a interactive-television classroom. Yacci (1995) examined student choice within learning environments and found eight learning patterns.

We believe it to be more functional to look at interactions by the coherence of messages sent between the two entities. If we consider interactivity to be more than the sum of its parts, then it is more than simply stringing messages together, or more than *who* sent a message *to whom*. We should find common patterns of interactivity that can be used to help understand mutual coherence.

The term 'patterns' represent a body of emerging literature from the software engineering field, albeit borrowed from its roots in architecture. *Patterns* represent prototypical situations that occur. They are generally told as "stories" that explain a single case, but provide solutions that are applicable to a representative set of cases (see Rising, 1998; Brown, Malveau, McCormick,& Mowbray, 1998). In the section below, we describe patterns that are typical of instructional interactions. These are not meant to be all-inclusive categories; there are always more stories that can be told; there are always more patterns that can be found. These interaction patterns are intended to describe common situations. As is sometimes typical of patterns, a short colloquial phrase is used as a tag for ease of remembering the pattern. These patterns are listed in Table 2.

Mutually Coherent Patterns	
Cognitive	declarative knowledge procedural knowledge

	structural knowledge extra-instructional action in environment
Affective	statement of affect multiplexed (hidden)

Table 2: Common Mutually Coherent Patterns

We believe there are at least five common content learning interaction patterns that occur during instruction and two common affective interaction patterns. Mutual coherence is probably best understood by examining these patterns.

Content Learning Patterns

There are five common patterns that deal with content learning: (1) declarative knowledge pattern, (2) procedural knowledge pattern, (3) structural knowledge pattern, (4) extra-instructional pattern and (5) activity in the environment pattern.

Declarative Knowledge Pattern ("correcting the facts")

The first type of content learning interaction involves a student message that is declarative knowledge--a statement of fact. This might be in response to a teacher question that has a factual answer, or simply a student expressing what he or she believes to be the truth concerning a situation. A statement of fact is sometimes called a proposition. A proposition has a truth value; that is, a proposition is either true or false. When a student makes a statement that is a proposition, an appropriate teacher response is to verify the truth of the proposition or to signify its falseness. A teacher response could vary from simple knowledge of results ("you're wrong") all the way through supplying the corrected proposition.

Procedural Knowledge Pattern ("shoring up the steps").

A second type of interaction involves the student's attempt to apply a rule in a new setting--the process of generalization. In these cases (called rule using or defined concept learning by Gagne & Briggs, 1979) a student is not searching memory for a proposition, but instead is using a form of rule based knowledge, sometimes called a production system (E. Gagne, 1985) or referred to as procedural knowledge. In these cases, the student message is similar to a hypothesis. That means that there are shades of gray in the way that the rule is applied, and that the "truth" of the behavior is less clear. Teacher response in these situations needs to go beyond simple knowledge of results or simply telling a student his or her answer is incorrect. The student needs to know *why*. For example, knowledge of results in a concept identification task is generally thought to be less effective than more detailed feedback explaining why the student's application of knowledge may be faulty (Smith & Ragan, 1993).

Structural Knowledge Pattern ("why do you think like that?")

A third type of student message might be called a statement-of-value that represents one's unique structural knowledge (Jonassen, Beissner, & Yacci, 1993). Within this pattern, each student expresses an opinion on a topic that is expected to be somewhat unique to that student. Often, they represent a complex causal chain of reasoning that is not yet "mature." An example of this type of statement might be, "Women are currently exploiting men in the work force." The response to such a statement might take several forms. The response may simply accept this opinion, in which case an acknowledgement that the message was received might be an appropriate response. A teacher or fellow student may wish to challenge the validity of the statement, by expressing a negative or contradicting opinion. The teacher or fellow student may request an *explanation*. In any of these cases, there is no "right" answer for a student to learn, and the type of interaction is quite different from others in which the student is learning what the teacher has already digested.

Extra-Instructional Pattern ("tell me more").
A fourth type of mutual coherence could be thought of as a simple request from the student for additional information. This is referred to as *extra-instructional feedback* by Kulhavy and Stock (1989). In this pattern, the learner requests additional information to be brought into the instructional situation. We would probably see this as a request for clarification. It should be noted that this request does not need to be directed at the teacher--it may be directed at classmates in a group learning situation.

Activity in the Environment Pattern ("does this do anything?").
Yet another type of content learning interaction is one of learner activity with the environment. In this pattern of interaction, the learner's "message" is an overt action or a simulation of overt action. The teacher or system response may take one of two forms: it may report back the natural consequences of the act, or it may report enhanced feedback that describes the consequences of the act with more salience. For example, in a business simulation, a student may make a change in his or her investment. The actual result of that change may not occur for simulated years. Natural feedback would do nothing in the short-term, and would allow a student to learn the results of his or her action as they would naturally occur. Artificial feedback, on the other hand, might provide an immediate comment to help focus the student's attention on an element in the environment. The value of feedback and experimentation in simulation and microworlds is supported by numerous authors (Senge, 1990; Rieber, 1994). Alessi and Trollip (1991) suggest a complex, often curvilinear gradient of the relationship between simulation fidelity and student readiness. Using their ideas, we could conclude that each type of feedback to student action has an appropriate degree of realism based upon student experience.

Affective Patterns

There are two patterns that deal with affective messages: (1) a statement of affect pattern and (2) a multiplexed affective pattern.

Statement of Affect Pattern ("I got it bad...")
A student may send affective messages that clearly state a particular need within the student. These messages may take the form of overt physical action or verbal statements. This type of message signifies that the student has a particular affective need. For example, a student may say "It sure is lonely out here in South Dakota studying calculus all by myself." A teacher may interpret this as a statement in which a student is letting it be known that he or she has a need for affiliation. Perhaps the student would like to make personal contact with another student or with the instructor. The teacher response to these affective statements could be to either validate the affective need, or to present counter-evidence that would help change the student's opinion of his or her need. For example, a teacher might respond "Yes, there is always a certain degree of separation and loneliness when taking distance courses." Or the teacher may respond, "Other students seem to think that there is *more* opportunity to communicate in these types of classes. With e-mail you are never alone." The first response validates the need in the student while the second response tries to alter the student's perception of his or her need. These seem to be typical of teacher responses to affective need messages; professionally trained counselors would undoubtedly have more alternatives in dealing with emotional issues.

Affective messages are not always negative. For example, an expression of joy might signify the need to express outwardly one's pleasure, or perhaps signifies a need for attention or recognition.

Multiplexed Affective Pattern ("hiding my feelings").
A second pattern of affective messages is far more difficult to detect. A multiplexed affective message is one that is hidden between the words of an otherwise benign statement. A discussed previously, a multiplexed message conveys emotion using tone of voice, emoticons, or perhaps (less noticeably) through word choice and "tone." In these cases, a response message may be detecting emotion that is actually *unknown to the sender*. Typical responses might be to note the emotional tone and request clarification ("Your note reads like you are very excited. What's going on?") or to ignore the affective component.

It should be noted that there are arguably many other ways to look at mutually coherent patterns. It should be considered an open area of inquiry to resolve whether the patterns used in this article are overly reductionist, and whether there are more useful patterns of mutually coherent patterns.

Uses of the Structural Model

Speculatively, we offer a hypothesis based on the structural model so far presented. It would appear that is most appropriate for an instructor to close the loop of each individual message in the cluster, in a mutually coherent way. That would mean, for example, that if a student were to send a clustered message containing (1) a statement of fact, (2) a statement of opinion, and also (3) a statement of affective need, then the teacher should ensure that the response contained mutually coherent responses for each message.

In distance learning courses there are often more messages transpiring a between teacher and student than might be typical in a classroom. The level of detail required to respond to each message within a lengthy clustered message is likely to overwhelm the average distance learning instructor without technological assistance. A mechanism to keep track of the various components of a clustered message may need to be built-in to distance learning environments. If each "thread" of the student message requires its own response, an e-mail system will need to keep track of these threads and be able to combine them into a single clustered response. Along those lines, providers of real-time distance "auditorium" software suggest that two people be involved in the course: one as a presenter and one as a moderator responsible for managing the complex interactions that occur (Jacobs, 1999).

To be able to program computer systems such that they produce human-like communication qualities (so that we may learn *from* them), we need to have a fairly clear idea of what those qualities are. For example, one of the first intelligent systems capable of mimicking human interaction was a program developed by Joseph Weizenbaum in the 60's entitled Eliza. Eliza mimicked the role of a Rogerian therapist, by "echoing" back phrases and concepts that appeared to be important to the user. Eliza succeeded in replicating the basic structure of human communication, although the program displayed nothing that we would consider as "intelligent" by today's standards. Nonetheless, Eliza showed us that the mutual coherence of human communication can be easily replicated (at least superficially) by machine.

It remains an interesting question whether some form of consistent but "fake" interactions, such as those produced by Eliza, would produce content learning and affective effects that are superior to those of a human teacher. While undoubtedly a human is capable of far more complex and subtle interaction messages, the computer might succeed *simply due to its diligence.* That is, the computer would never fail to respond; the computer would complete every interactive loop.

Conclusion

This structural definition of interactivity perhaps runs counter to some current trends in instructional design in which the very existence of the communication act is brought into question (as in constructivist theory). Truthfully, the structural approach is reminiscent of behavioral explanations for learning that may have gone out of favor. However, structural definitions are valuable for providing insight into complex situations. We believe that the basic structure of interactivity, once documented, is simple to grasp; since it does not specify how learning takes place, it may be found to be consistent with some aspects of constructivist theory.

Paradoxically, it is because *interactivity* is such a ubiquitous activity that we may fail to provide reasonable definitions for the term. Perhaps we assume that others automatically know what we are talking about. Or, perhaps we are seeking the "silver bullet" of instruction and wish to sanctify the term. Making clear the mechanics of interactivity tends to destroy its mystique.

It is hoped that this general model begins to make evident some of the variables in distance education and interactive instruction that may have been hidden because of the lack of a clear process definition. Simon (1969, pg. 56) tells that classification research is valuable because it clarifies one's understanding of a phenomenon. "You may find that the argument has suddenly evaporated..." when both parties agree upon a working definition of terms. In providing this definition, it is not our intention to substitute our speculations for empirical research; rather it was our hope to provide a general structure such that future research findings dealing with interactivity can come together.

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