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ANALYSIS OF A GLOBAL ONLINE DEBATE AND THE DEVELOPMENT OF AN INTERACTION ANALYSIS MODEL FOR EXAMINING SOCIAL CONSTRUCTION OF KNOWLEDGE IN COMPUTER CONFERENCING

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ABSTRACT

This study attempts to find appropriate interaction analysis/content analysis techniques that assist in examining the negotiation of meaning and co-construction of knowledge in collaborative learning environments facilitated by computer conferencing. The authors review strengths and shortcomings of existing interaction analysis techniques and propose a new model based on grounded theory building for analyzing the quality of CMC interactions and learning experiences. This new Interaction Analysis Model for Examining Social Construction of Knowledge in Computer Conferencing was developed after proposing a new definition of "interaction" for the CMC context and after analyzing interactions that occurred in a Global Online Debate. The application of the new model for analysis of collaborative construction of knowledge in the online debate and in a subsequent computer conference are discussed and future research suggested.

INTRODUCTION

The exchange of messages among a group of participants by means of networked computers, for the purpose of discussing a topic of mutual interest, is referred to as computer-mediated conferencing or computer conferencing. Computer-mediated conferencing is presently being employed with greater and greater frequency as an environment for collaborative learning. However, the utilization of the medium in education has in many respects outstripped the development of

theory on which to base such utilization. One significant question which has not yet been satisfactorily answered is how to assess the quality of interactions and the quality of the learning experience in a computer-mediated conferencing environment.

Questions that are often asked in the assessment or evaluation of computer conferences related to participation patterns and participant satisfaction with the conference have been answered fairly successfully using several methods. Among them are participation analysis techniques which analyze the capacity of a conference to engage members or which analyze comparative patterns of participation among learners from varying backgrounds [1, 2]. Participants' own reports of learning or satisfaction with the learning experience are also important; these may be studied as found in the transcript of a conference or by means of online or paper surveys. However, while participation analysis techniques have value in determining who participated, how actively, and for how long, neither quantitative analysis of participation nor reports of particular satisfaction yield information on the construction of knowledge or the quality of learning that took place in a computer conference. In order to assess the quality of interactions and the quality of the learning experience in a computer mediated conferencing environment, content analysis or interaction analysis of computer transcripts is essential.

Mason, in her review of methodologies for evaluating computer conferencing, notes that most research stops with quantitative analyses based on number of messages sent, and by whom, or on frequency of logons, or on message maps showing numbers of replies and message chains [3]. Many studies used surveys, interviews, case studies, empirical experimentation, and statistical measurements to evaluate computer conferencing, but these do not shed much light on the quality of learning taking place. Mason urges researchers to take up the more challenging methodology of content analysis in order to answer more crucial questions related to the quality of learning and knowledge construction that occurs through social negotiation in CMC.

PURPOSE

The purpose of this article is to critically examine interaction analysis techniques that have been developed for the analysis of computer conferences and determine which techniques work best in a given context to address specific research questions. This study is interested in finding appropriate interaction analysis techniques that help address the following two evaluation research [4] questions:

1. Was knowledge constructed within the group by means of the exchanges among participants? and

2. Did individual participants change their understanding or create new personal constructions of knowledge as a result of interactions within the group?

The article will examine the definition of "interaction" in a computer-mediated communication (CMC) environment as definitions of "interaction" for interpersonal communication used by communication researchers to study face-to-face dialogue do not transfer well to the CMC context. The article will point out the strengths and shortcomings of interaction analysis techniques that have been developed and will propose a model based on grounded theory building [4] for analyzing the quality of CMC interactions and learning experiences. The interaction analysis model will be developed by analyzing the interactions that occurred in a global online debate conducted through computer conferencing; the authors contend that the debate forms a particularly good example of collaborative construction of knowledge through social negotiation, a key feature of a constructivist learning environment [5]. The application of this model for analyzing the global online debate as well as another professional development computer conference will be discussed.

The detailed examination of transcripts provides both theoretical and practical insight into the learning context and its outcomes. For many students, teachers, and researchers, text based, asynchronous interaction is a novel environment, with only short developmental history upon which to base quality assessment. Techniques and systems developed in this article are critically important to developing theoretical understanding of what occurs during the learning process and as importantly they provide tools by which practitioners can assess and then modify the learning sequences and activities they facilitate.

THE INTERNATIONAL ONLINE DEBATE

The online debate took place during the week of June 5-11, 1995, and formed part of ICDE95 Online, a virtual pre-conference to the XVI World Conference of the International Council on Distance Education (ICDE) held in Birmingham, England. The online pre-conference provided an opportunity for those who could not attend the conference to discuss by CMC issues that would be addressed during the Birmingham conference [6].

A major goal of the ICDE95 online conference was to demonstrate and develop effective learning activities which support quality virtual conferences. The leaders of each session were responsible for carrying out the selected learning activity in such a way as to maintain interest and participation throughout one week. The learning activity selected for the first conference session was the online debate, one of the first experiments in running a debate across international time lines on the Internet. Terry Anderson, one author of the present article, was overall moderator and technical coordinator for the entire conference; authors

Gunawardena and Lowe designed the debate with graduate students at the University of New Mexico and led the affirmative debate team. The ICDE95 online debate is hereafter referred to as "the debate."

The debate design invited the 554 list subscribers to participate on either the affirmative or the negative side of a statement presented by the debate leaders. Each team was headed by a leader and each day's contributions were reviewed at the end of the day by a second team member, the "summarizer." In addition to the authors, other team leaders and summarizers were located at the George Washington University at Washington DC, and the Pennsylvania State University at University Park, Pennsylvania. One major challenge of this project was to design a debate which allowed equal opportunities for participants to contribute even though they were located across international time lines. While asynchronous CMC is a good medium for this kind of activity, the debate format requires adherence to time lines if it is to function as a debate. The debate designers adopted a structure which was divided into days measured according to Greenwich Mean Time (GMT).

On the day before the debate began, the topic for the debate, the definition of the topic, and the rules and format of the debate were posted to list subscribers. The schedule on which arguments were to be posted was as follows:

Monday, June 5, 00:01-23:00 GMT—First Affirmative posted by Team Leader. From the time this statement appeared until 23:00 GMT, everyone who wished to argue in favor of the proposition (statement) was asked to add their comments. Between 23:00 GMT and midnight, a summary of the day's arguments was posted by the summarizer for the Affirmative side.

Tuesday, June 6, 00:01-23:00 GMT—First Negative posted by Team Leader. From the time this statement appeared until 23:00 GMT, everyone who wished to argue against the proposition (statement) was asked to add their comments. Between 23:00 GMT and midnight, a summary of the day's arguments was posted by the summarizer for the Negative side.

Wednesday, June 7, 00:01-23:00 GMT—Affirmative Rebuttal. Those who favor the proposition were asked to argue against the statements made the previous day by the Negative Team. Between 23:00 GMT and midnight, a summary of the day's arguments were posted.

Thursday, June 8, 00:01-23:00 GMT—Negative Rebuttal. Those who opposed the proposition were asked to argue against the statements made on Monday and Wednesday by the Affirmative Team. Between 23:00 GMT and midnight, a summary of the day's arguments were posted.

Friday, June 9, 00:01-23:00 GMT—Affirmative Restatement. Those who favor the proposition were asked to answer the arguments raised the previous day by the Negative Team and restate their case. Between 23:00 GMT and midnight, a summary of the day's arguments were posted.

Saturday, June 10, 00:01-23:00 GMT—Negative Restatement. Those who oppose the proposition were asked to answer the arguments raised the previous day by the Affirmative Team and restate their case. Between 23:00 GMT and midnight, a summary of the day's arguments were posted.

Sunday, June 11, 00:01-23:00 GMT—Volunteer judges were invited to discuss the outcome of this debate.

The adherence to GMT was emphasized in the rules posted in order to be sure that all participants, wherever they were located in the world, would be able to take their turns during the twenty-four hour time periods reserved for their chosen teams. All participants were asked to use the following subject lines when they participated in the debate:

1. "Interaction Affirmative" for arguments in favor of the proposition.
2. "Interaction Negative" for arguments opposing the proposition.

The topic chosen for the debate focused on a controversial issue in current research in distance education, the role and importance of "interaction" in effective distance education. In order to maximize the difference in opinion represented by the positive and negative sides of the debate, this controversy was deliberately reduced to the extreme statement: "No Interaction, No Education," representing the assertion that true distance education is impossible without provision for interaction. Detailed discussion of the design of the debate is found in Gunawardena, Lowe, and Anderson [7]. The debate transcript is archived in the World Wide Web at (http://www.ualberta.ca/~tanderso/icde95/interaction_www/).

The primary tool used to support ICDE95 was an unmoderated, open Listserv [8] mailing list maintained at the University of Alberta. List participants represented approximately thirty-five countries. Most participants in the debate were practicing specialists and advanced students in the field of distance education. Due to the characteristics of the participants, who were predominantly professionals in the field of distance education, and the sharp focus of the conference which resulted from use of the debate format, the conference offers a particularly good example of the use of the computer conferencing medium in the co-creation of knowledge.

THEORETICAL FRAMEWORK FOR EVALUATION OF QUALITY IN COMPUTER CONFERENCING

A number of models for the evaluation of quality in computer conferencing are available. Hiltz describes analysis of computer conferences along four dimensions: 1) characteristics inherent to the technology, 2) social and psychological characteristics of users, 3) characteristics of groups adopting the technology, and 4) interaction of the preceding factors [2]. Levin, Kim, and Riel describe a

method of analyzing the structure and content of interactions by the creation of "message maps" which display graphically the interrelationships among the messages submitted to a conference [1]. Levin and colleagues use this analysis to identify "threads" within a conference and to display the "multithreaded" nature of conference interaction [1]. They also practice identifying messages which are particularly "influential" in producing numerous responses or lengthy sequences of responses and they diagram message flow described as the ebbing or flowing volume of messages in the conference. Henri proposes a system of content analysis which involves breaking messages down into units of meaning and classifying these units according to their content [9]. Henri includes a quasi-quantitative "participative" dimension of analysis in her scheme for content analysis which the authors feel is more properly considered as a separate issue from the more qualitative analysis of message meaning units. Henri's other four broad categories of content are described as 1) content which reflects the social dimension of conference interchanges, 2) content relating to the interactive dimension of the conference, 3) content indicating the application of cognitive skills, and 4) content showing metacognitive skills. Newman and colleagues [10, 11], in an attempt to study the quality of the learning experience in a computer conference, have applied Henri's model [9] and Garrison's model of critical thinking [12] to develop a content analysis method to measure critical thinking in face-to-face and computer supported group learning. They observe that the stages listed in Garrison's description of critical thinking as a five-stage process correspond closely to the cognitive skills Henri recognizes as important to the cognitive dimension of CMC.

These models serve as a useful starting point for analyzing CMC interactions. However, they are not very specific on how to evaluate the process of knowledge construction that occurs through social negotiation in CMC. Moreover, the definitions of interaction these models present are either unclear or not very applicable to the pattern of interaction observed in the debate.

ISSUES IN THE ANALYSIS OF THE DEBATE

The online debate was designed as an adult professional development experience and participants were either practicing professionals in the field of distance education or graduate students conducting research in the field. The participants could be described as a group of professionals of roughly equal stature coming together to contribute their knowledge, negotiate meaning, and come to an understanding about an important issue in the theory and practice of distance education. Therefore, the interaction that occurred among the participants could be described as a collaborative construction of knowledge through social negotiation, or a constructivist learning experience [5], rather than a one-way dissemination of information from an expert group to a novice group. The dynamics of this group of equal participants were also very different from the dynamics of a class led by

a teacher or group of experts. Interaction analysis models that have been developed to analyze online class interaction in a "teacher-centered" learning environment may not be very appropriate, or may have to be extensively adapted, for analyzing the interaction that occurs in professional development experiences of this kind.

The following factors had to be kept in mind as we approached the analysis of the debate transcript:

- The debate format described earlier imposed an organizational structure which influenced the interactions. Since the debate format required participants to take sides on an issue, those who wanted to argue on middle ground found it difficult to fit their statements into either the affirmative or negative category and to decide on which days they should post their arguments. A related problem was that, due to technical transmission delays, some of the messages did not get posted on the days they were sent.
- A predominant influence of the debate format could be seen in the way it affected the co-construction of knowledge. While the format supported well the discussion of inconsistency among ideas, it kept the participants from negotiating meaning to reach a compromise. The debate leaders, in the spirit of competition appropriate to a debate, tried to keep their teams focused on winning the argument and discouraged the group from trying to achieve a consensus or compromise.
- Determining a unit of analysis was also a problem with this format. Participants often apparently felt that they had to put forth several arguments to prove their point and, therefore, each message was likely to include several arguments which advanced the case. Consequently, separating a message into meaning units following the Henri model [9] was difficult.
- The majority of messages in the debate were very task oriented, as it was a highly structured activity for a period of one week. The debate lacked the socialization element that is usually characteristic of many computer conferences. This may have discouraged some participants from contributing.

ANALYSIS OF THE DEBATE TRANSCRIPT BASED ON PREVIOUS INTERACTION ANALYSIS MODELS

Jordan and Henderson describe interaction analysis as an interdisciplinary method of investigating the interaction of human beings with each other and with objects in their environment [13]. Quoting Garfinkel, they observe that interaction-analytic studies see learning as a distributed, ongoing social process, in which evidence that learning is occurring or has occurred must be found in understanding the ways in which people collaboratively do learning and recognize learning as having occurred. Fortunately, a computer transcript provides the kind

of data corpus that allows the close scrutiny for interaction analysis. Interaction analysis employs content analysis techniques and focuses on studying the interactions that took place between participants. Jordan and Henderson point out the difficulty of describing interaction analysis and note that it is best learned by doing, usually in a dyad or in a group.

The methodology adopted in developing a framework for analyzing the quality of the learning experience of the debate included several stages. The first stage was a critical review of currently available interaction analysis models and their definitions of interaction and interaction analysis. Next, the applicability of currently available models for the analysis of the debate was tested. Then, in order to overcome the shortcomings seen in the application of previous models, a new definition of interaction was put forth and the learning environment that emerged in the process of the debate was described. This was followed by the analysis of the debate transcript to examine emerging patterns, themes, and phases related to the social construction of knowledge. Finally, an interaction analysis model was developed for analyzing the themes, patterns, and phases that emerged from the debate. Thereafter, the model was applied to the analysis of the debate itself.

Based upon the review of models discussed in the above section, and other published models for analyzing interactions in computer conferences [3], the authors selected Henri's [9] model as the most promising starting point for the interaction analysis of the debate transcript. The authors agreed with Henri that computer conferencing is characterized by exceptional "richness and efficiency" and that examination of the actual content of messages is the appropriate means of evaluating whether or not the learning experience has made full use of the potential of the medium. A decision was made to focus the content analysis of the debate transcript on meaning units which Henri would describe as having cognitive or metacognitive content.

One important aspect of the Henri [9] model which the authors chose not to examine in evaluating the debate was the "social" content of conference messages. Henri describes social message content as "Statement or part of statement not related to formal content of subject matter." Examples cited by Henri include statements of self-introduction or mutual support among learners. The authors agree that such statements are important in establishing social presence, building rapport, and promoting the growth of community, especially in the construction of a learning environment which is meant to join a set group of learners for an extended period of time. However, the structured debate format did not lend itself to social interaction and kept the participants task-oriented for a period of one week. Thus, while it is important to analyze the social dimension in other conferences, the authors decided it was not appropriate in the context of the debate.

Of the five dimensions for evaluation proposed in the Henri [9] model, the authors felt that the participative dimension, which Henri defines as the compilation of the number of messages or statements transmitted by one person or group, should be studied separately from the fundamentally qualitative analysis of

message content because this type of analysis does not shed light on the quality of the learning experience. Since for the reasons noted above the social dimension of Henri's model was also set aside, the content analysis of the transcript focused on the remaining three aspects of the model: content relating to the interactive dimension of the conference, content indicating the application of cognitive skills, and content showing metacognitive skills.

One of the first steps in conducting the interaction analysis was to decide on the unit of analysis. Henri suggests dividing messages into "units of meaning" because a message may contain more than one idea [9]. The debate transcript was thus cut up into units of meaning (sometimes one statement and at other times one or two paragraphs in a message). This was a very difficult process as we felt that cutting up a message into units did not capture the essence of meaning expressed in that message. The units of meaning were then scored on Henri's three dimensions selected for this study: interactive, cognitive, and metacognitive. With respect to the interactive dimension, a message map was created showing the extent to which messages were interrelated. Here, a message was considered the unit of analysis rather than a "unit of meaning," as defined by Henri, because using a "unit of meaning" to determine interaction patterns became very complicated. Instances of cognitive processing, as expressed in "units of meaning" were coded following Henri's definitions for surface level and in-depth processing. A separate analysis was done of the amount of metacognitive knowledge and skills that appeared in message units. As the content analysis of the debate transcript progressed, it rapidly became clear that many aspects of Henri's model were unsuited for application to the debate.

The first shortcoming the authors found in the Henri model [9] as applied to the debate is that, while Henri notes the advantages of CMC for collaborative work, the model still appears to be based on a teacher-centered instructional paradigm. For example, Henri states that ". . . the educator can offer input at three levels: what is said on the subject or theme under discussion; how it is said; and the processes and strategies adopted in dealing with it . . . The educator may favor one or another level, according to his or her pedagogical aims and intentions" [9, p. 123]. The paradigm Henri describes here is clearly one widely applied, as educators new to distance education try to recreate the familiar patterns of traditional teaching in a new medium. However, it is also clear that such a paradigm is inappropriate for analyzing voluntary and informal continuing professional education, as represented in the debate and other online discussions such as e-mail lists and Usenet groups which feature exchange of views among adult professionals. Therefore, in the analysis of Henri's three dimensions selected for this study, a move from a teacher-centered view of learning to constructivistic conceptions of learning based on shared construction of knowledge seems more appropriate. In the debate, the objective was to evaluate the learning process taking place among the group of participants, rather than to assess individual student performance.

The debate could be described as a constructive learning environment that provided multiple perspectives and real world examples of the topic of discussion ("interaction in distance education"), that encouraged reflection, and that supported collaborative construction of knowledge through social negotiation [5]. The participants brought to it roughly equal levels of knowledge and roughly equal cognitive/metacognitive skills; the learning which took place occurred by collaborative construction of knowledge and negotiation of meaning. Analysis of the conference transcript should therefore focus upon transactions among the participants in which knowledge is shared and negotiation of meaning occurs.

Therefore, breaking up individual messages into "meaning units" and analyzing them according to Henri's [9] cognitive dimension as surface (for example, elementary clarification) and in-depth processing (inference, judgement) was not really getting at the learning process that was taking place among the group of participants who were engaged in negotiation of meaning and collaborative construction of knowledge. The analysis based on Henri's model indicated the presence and frequency of participants employing cognitive skills, but did not explain the learning process taking place within the group through the process of interaction among the participants. Newman and colleagues [10, 11] who used Henri's [9] model for content analysis observe that they had similar problems. They note that while in principle it is possible to classify statements in a transcript by Henri's cognitive skills according to her indicators, Henri herself has acknowledged [9] that the analysis can generate superficial results telling us only the presence and frequency of using these skills.

The next problem we found with Henri's [9] model was that when coding units of meaning according to the metacognitive dimension (thinking about thinking and self-awareness), it was difficult to distinguish between the cognitive and the metacognitive dimensions as Henri had done. A large number of units of meaning could be coded both as cognitive and metacognitive. Most meta-knowledge expressed was in relation to the task or task evaluation, but there were many occurrences of meta-knowledge expressed in relation to people and strategies used as well. Self-awareness was also expressed in relation to task, person, and strategies. Because of the difficulty in making a distinction between cognitive and metacognitive statements, we felt that in the context of the debate, it would be better to reframe them as strategies in the co-creation of knowledge and negotiation of meaning characteristics of a constructivist learning experience.

The third objection to Henri's [9] model and its theoretical foundations is its treatment of the concept of interaction. Henri suggests breaking message content into meaning units and classifying them under five dimensions, one of which is "interactive." Henri explains that interactive content consists of meaning units clearly linked to one or more preceding messages. Henri states that messages are either "monologic" or "interactive" and then suggests further analysis based on observing whose messages garner the most response. This is similar to Levin and colleagues identification of"influential messages" [1]. Henri's [9] examination of

"interactivity" as linking between messages seems to be similar in some respects to Levin and colleagues [1] construction of "message maps." This kind of analysis merely describes the pattern of connection among messages, and not the entire gestalt to which the messages contribute. While truly monologic messages occasionally do appear, the authors feel that this is the exception rather than the rule: generally speaking all the messages in a conference are linked; all respond to each other and to the emerging totality of constructed knowledge, regardless of whether a message can be identified as responding to another specific message or group of messages. The analysis of the debate transcript according to Henri's [9] interactive dimension revealed similar results. Practically all messages could be linked to other messages and to the theme of the debate. Indeed, the debate format necessitated the linking of messages as participants built upon or refuted previous arguments. Thus, Henri's [9] interpretation of interaction is mechanistic and descriptive, but not central to the construction of knowledge. We feel that the crucial importance of interaction for the social construction of knowledge in a constructivist learning environment cannot be overemphasized. Interaction is the process through which negotiation of meaning and co-creation of knowledge occurs.

As seen in the debate transcript, "interaction," should be viewed as the totality of interconnected and mutually-responsive messages, which make up the conference, and perhaps more: "interaction" is the entire gestalt formed by the online communications among the participants. The participants are not speaking in the same virtual space by chance and regardless of each others' presence; they are acting in relation to each other and in a manner which reflects each others' presence and influence. They are not merely acting, nor reacting, but interacting, even if the links among individual messages may not be readily apparent. The process that was observed in the debate is akin to Salomon's [14] thinking on "distributed cognitions," where he states that individual and distributed cognitions interact over time, affecting each other and developing from each other. Models of distributed cognitions try to explain how processes such as problem solving or decision making actually emerge from the work of many different cognitive processors that independently activate, transmit, transform, and create knowledge [15].

Models such as Levin and colleagues [1] and Henri's [9], which link message to message in "threads" of successive, specifically-joined responses, focus on a mechanistic relationship rather than the learning experience as a totality. We are all capable of holding multiple considerations, or threads of argument, in mind as we examine a subject, a fact which Henri's practice of breaking messages into "meaning units" may actually obscure; we must not, without realizing it, begin to view discussion artificially divided into strands of arguments as a fair representation of the participants' interaction or any individual participant's learning process. That is the problem we encountered when applying Henri's [9] and Levin's [1] interaction analysis models to the debate. For example, the topic of

the debate was interaction in distance education. Arguments advanced during the debate dealt with the cost of providing access to interaction, the effect of interaction in promoting learner persistence, the need to provide alternative media for use in interaction, and the desire of some learners to avoid interaction. The knowledge created during the debate regarding "interaction" included knowledge of these aspects of interaction, and yet the concepts of interaction which emerged was larger than the sum of these parts.

Given the problems we encountered in our analysis of the debate according to Henri's [9] three dimensions: interactive, cognitive, and metacognitive, we decided to develop a framework of interaction analysis that would be more appropriate for analyzing the debate transcript to answer our research questions. The steps in this process included examining theoretical frameworks, definition of our concept of interaction in a computer conference, and analysis of the debate transcript to examine emerging patterns, themes, and phases related to the social construction of knowledge.

THE DEVELOPMENT OF A FRAMEWORK FOR INTERACTION ANALYSIS

Theoretical Framework for Examining Social Construction of Knowledge

Pea observes that "Knowledge is commonly socially constructed, through collaborative efforts toward shared objectives or by dialogues and challenges brought about by differences in persons' perspectives" [15, p. 48]. He quotes Vygotsky, who emphasized the ways in which the character of social interactions and externally mediated action makes explicit certain processes that come to be internalized in the private thought of the individual [16]. Vygotsky, most often associated with "social contructivist theory" stresses the influences of cultural and social contexts in learning.

Smith notes that activity theory developed in the first half of this century in the Soviet Union associated with Vygotsky and his followers includes several key concepts that are useful for understanding collaboration in groups [17]. These include "situated activity, mediating devices, higher and lower mental functions and the zone of proximal development." Smith looks at collaborative behavior in groups through these concepts. He notes that activity theory asserts that mental behavior is situated within the cultural and social contexts and is affected by those contexts. For collaborative groups the context includes the organization in which the group functions, or the group itself. In order to explain how mental processes can be influenced by social factors, Vygotsky differentiated between what he called lower and higher mental functions [16]. For example, the basic act of remembering facilitated by one's neural apparatus, is a "lower level" function, but when people learn to use mediating devices such as mnemonics as tools for

remembering, they have more conscious control over memory-related processes which can be described as a form of "higher" mental function. Smith [17] argues that Vygotsky's distinction between lower and higher mental functions can be applied to a group's collaborative skills. As a group learns to work together more effectively, the successive stages they go through may be considered forms of higher mental functions. He observes that in computer conferencing, the computer mediated communication system itself may be a very strong "mediating device" (i.e., computer-mediated cognition) and the ideas voiced by other participants that influence one's own thinking, another form of "mediation" (i.e., group-mediated cognition). Smith notes that Vygotsky, in describing the "zone of proximal development," argued that before we can carry out a task by ourselves we must first learn the skill in proximity to another person, usually the relationship that exists between a novice and an expert. As the novice's ability develops, the expert curtails his or her participation, leading to the development of higher mental functions in the novice. In a computer conference, the experts can serve as expert models to novices in the group.

Smith, in defining group-mediated cognition ("gmc"), states that in situations such as group meetings the situation itself exerts a strong mediating effect on individual cognitive and conceptual processes [17]. That is, the thinking of each individual is inevitably influenced by the thinking of the other members taking part in discussion, even if it is only to disagree. He refers to this situated form of thinking as group-mediated cognition and states that the merger of intellectual and social processes is one of the two fundamental properties of group-mediated cognition. A second fundamental property is the tension between the individual and the group—that is, the tension between the conceptual structure that is held in common and shared by the group, and the slightly different versions of that structure that exist in individual working memories of the participants. Smith notes that this tension provides both the energy and the development operations that drive this form of collective processing. When an individual voices his or her opinion on how that common or core structure is linked to additional concepts, other members can apply this new information to structures in their respective memories and perhaps change those structures. In this way knowledge is extended. If the individual member's idea is accepted by the group, it will become part of the core conceptual structure that is shared by the group. According to Smith, when this happens the gmc cycle is complete.

We tend to under-emphasize the fact that two kinds of knowledge creation take place in any shared learning experience, the "individual" and the "social." Knowledge is created at the social—the level of the group—and the individual also creates his or her own understanding by interacting with the group's shared construction. Like Salomon [14] who sees individual and distributed cognitions as interacting over time, affecting each other and developing from each other, we believe it is important to recognize the interdependence of both the individual and the social construction of knowledge.

Roschelle [18] has noted that a unifying concept emerging from situated learning research (e.g., that of Brown, Collins, and Duguid [19]) is "communities of practice" where learning is seen as a construction of a social unit that shares a stake in a common situation. A community of practice arises through the coordinated use of technologies (broadly defined to include language) to arrive at mutually intelligible resolutions to shared problematic experience. A collaborative technology is a tool that enables individuals to jointly engage in active production of shared knowledge. For example, a storyboard is a tool that can enable script writers, set designers, and directors to construct a shared understanding of the film they aim to produce. Likewise, CMC enables a group separated in time and space to engage in active production of shared knowledge.

The description by Jonassen, Mayes, and McAleese [20] of constructivist learning environments embodies the principles discussed above. They note that constructivist environments facilitate the personal construction of knowledge about the external world. This process is facilitated by environments that represent multiple realities, that use real-world, case-based contexts for learning, and that facilitate collaborative construction of knowledge. These environments should be supported by tools that engage learners meaningfully. All of these activities can be effectively supported by technology-based environments.

Jonassen, Mayes, and McAleese also address the evaluation of constructivistic learning, emphasizing that constructivistic learning outcomes should be evaluated using evaluation methods that are sensitive to the goals of constructivistic learning [20]. They note that nearly every definition of constructivism refers to knowledge construction rather than reproduction, where learners are actively engaging in building knowledge structures. Thus, as evaluators we need to assess the intellectual processes of knowledge construction, not those of repetition. Knowledge construction necessitates higher order thinking, so outcomes of constructivistic environments should assess higher order thinking. This suggests new forms of assessment, emphasizing process variables such as how learners go about constructing knowledge, and qualitative variables such as the nature and content of learner interactions.

Definition of CMC Interaction from a Constructivist Perspective

The authors believe that a metaphor taken from the world of textile crafts better describes the process of shared construction of knowledge that occurs in a constructivist learning environment than does the "multithreaded" metaphor favored by Levin and colleagues [1]. According to the constructivist understanding, the participants in a computer-mediated conference are interacting to produce new knowledge or to arrive at new understandings of meaning. As shown in Figure 1, the image of a patchwork quilt block illustrates the authors' understanding of the significance of this interaction.

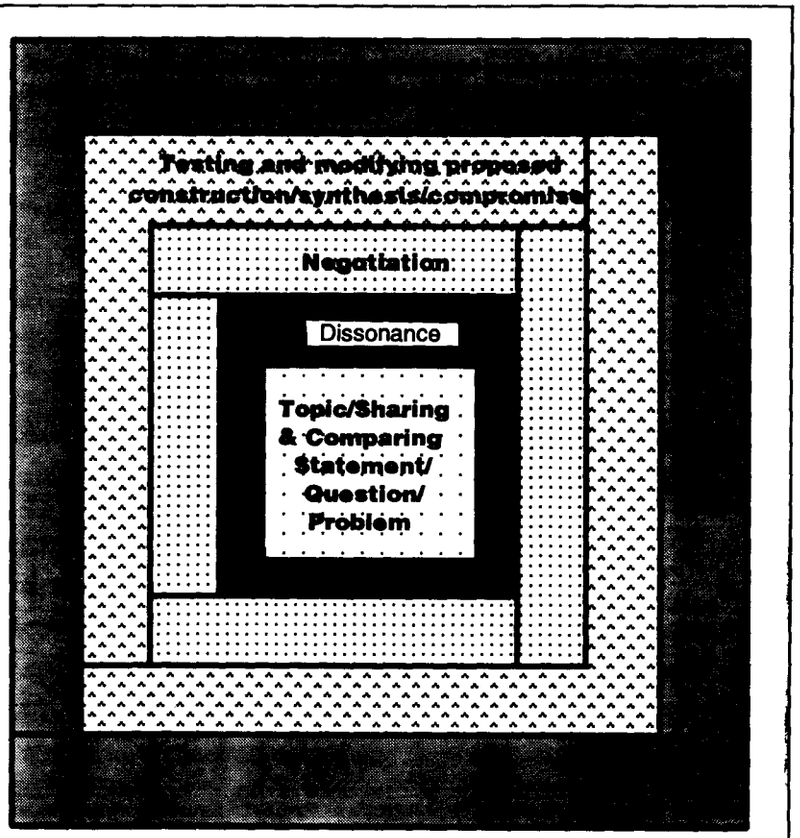

Figure 1. A constructivist model of CMC interaction.

A quilt block is built up by the application, one after another, of small pieces of cloth, which when assembled form a bright and colorful pattern. The pieces, according to this analogy, are the contributions of individual participants. Each participant contributes to the whole his or her own texture and color of thought, just as every scrap of fabric forms a distinctive element in the overall pattern. The pattern may not be complete during a single conference, but individual responses can contribute toward the formation of a pattern. The process by which the contributions are fitted together is interaction, broadly understood, and the pattern which emerges at the end, when the entire gestalt of accumulated interaction is

viewed, is the newly-created knowledge or meaning. Interaction is the essential process of putting together the pieces in the co-creation of knowledge.

Having determined that the debate represented a constructivist learning environment, in which interaction functions as the vehicle for co-creation of knowledge, the authors searched for a content-analysis model to apply to the conference transcripts. In particular, the authors hoped to find a rationale for determining by analysis of the transcripts that the co-creation of knowledge had occurred through the pooling of individuals' knowledge or that negotiation of meaning had occurred. No such model was to be found. The authors therefore proceeded to develop their own model based on the analysis of the debate transcript.

An Interaction Analysis Model for Examining Social Construction of Knowledge in Computer Conferencing

Based on the theoretical framework and the definition of interaction explained above, the authors began with describing the steps through which the construction of knowledge and negotiation of meaning took place in the debate. Our purpose was to develop a model using grounded theory principles [4], a model that would evolve through the content analysis of the debate transcript itself that would explain the process by which construction of knowledge occurred.

The questions uppermost in our minds were: 1) Was knowledge constructed within the group by a process of social negotiation? and 2) Did individual participants change their understanding or create new personal constructions of knowledge as a result of interactions within the group?

Based on our definition of interactions as the essential process of putting together the pieces of the quilt (contributions of participants) in the co-creation of knowledge we proceeded to analyze the entire transcript for the: 1) type of cognitive activity performed by participants (questioning, clarifying, negotiating, synthesizing, etc.), 2) types of arguments advanced throughout the debate, 3) resources brought in by participants for use in exploring their differences and negotiating new meanings, such as reports of personal experience, literature citations, and data collected, and 4) evidence of changes in understanding or the creation of new personal constructions of knowledge as a result of interactions within the group.

It rapidly became evident that such an analysis would involve a rather arbitrary division into phases of what in reality is a gradual evolution. However, this seemed unavoidable. The subjective nature of this type of analysis also became apparent as the researchers are clearly influenced by their own conceptual frameworks and cultural knowledge.

In the analysis of the debate transcript, it was at first puzzling how to interpret as "negotiation" exchanges which appeared to be largely in agreement. It appeared that two types of learning were occurring. It appeared that in the first,

more basic, type of learning, participants were active in each other's learning processes only by providing additional examples of concepts which in essence were already understood. This type of learning could be called "learning by accretion," or pooling of knowledge. ("Elaboration" is another term used in reference to this kind of learning at the level of the individual.) The process of negotiation was more evident with respect to a second type of learning: that which actually required participants to adjust their ways of thinking to accommodate new concepts or beliefs inconsistent with their pre-existing cognitive schema.

Upon closer examination, however, it became clear that this distinction was to some degree artificial; tacit negotiation was continually occurring even when participants were apparently in agreement. The work of Lakoff in describing the importance of categorizing functions in the evolution and use of language within cultural groups suggests an example of how this may be so [20]. In effect, when participants offer corroborating experiences or examples, they are proposing that those examples belong in the same category as preceding examples. The unspoken negotiation which occurs within the group each time a new example is offered results in a determination whether or not the example fits within the shared category boundaries (or within acceptable limits of ambiguity beyond the category boundaries). It is when an example cannot be made to fit within agreed-upon boundaries that negotiation must become overt and the co-construction of knowledge becomes visible. Either the group then changes the boundaries of the category, or a new category is proposed, and so on.

Based upon these observations, the authors next arrived at an outline of the process of negotiation which appears to occur in the co-construction of knowledge. The outline has five phases, reflecting the complete process of negotiation which must occur when there are substantial areas of inconsistency or disagreement to be resolved. However, where there is less disagreement within a group, negotiation may remain largely tacit and the process may conclude at one of the earlier phases, as described above. The phases of learning outlined in this model occur at both the individual and social level.

Figure 2 outlines in more detail the five phases of knowledge co-construction that the authors believe occurred during the course of the debate and which they believe characterize negotiation of meaning where participants are engaged in the social construction of knowledge in a constructivist learning environment. As outlined broadly in Figure 1, they are: Sharing/Comparing, Dissonance, Negotiation/Co-construction, Testing Tentative Constructions, and Statement/Application of Newly-Constructed Knowledge. Figure 2 identifies specific operations which may occur at each stage of the process.

Although metacognitive statements by participants illustrating that their knowledge or ways of thinking (cognitive schema) have changed as a result of the conference interaction appeared throughout the debate, we have included this operation in Phase V as part of cognitive activity. Metacognitive statements were

PHASE I: SHARING/COMPARING OF INFORMATION. Stage one operations include:

A. A statement of observation or opinion	[PhI/A]
B. A statement of agreement from one or more other participants	[PhI/B]
C. Corroborating examples provided by one or more participants	[PhI/C]
D. Asking and answering questions to clarify details of statements	[PhI/D]
E. Definition, description, or identification of a problem	[PhI/E]

PHASE II: THE DISCOVERY AND EXPLORATION OF DISSONANCE OR INCONSISTENCY AMONG IDEAS, CONCEPTS OR STATEMENTS. (This is the operation at the group level of what Festinger [20] calls cognitive dissonance, defined as an inconsistency between a new observation and the learner's existing framework of knowledge and thinking skills.) Operations which occur at this stage include:

A. Identifying and stating areas of disagreement	[PhII/A]
B. Asking and answering questions to clarify the source and extent of disagreement	[PhII/B]
C. Restating the participant's position, and possibly advancing arguments or considerations in its support by references to the participant's experience, literature, formal data collected, or proposal of relevant metaphor or analogy to illustrate point of view	[PhII/C]

PHASE III: NEGOTIATION OF MEANING/CO-CONSTRUCTION OF KNOWLEDGE

A. Negotiation or clarification of the meaning of terms	[PhIII/A]
B. Negotiation of the relative weight to be assigned to types of argument	[PhIII/B]
C. Identification of areas of agreement or overlap among conflicting concepts	[PhIII/C]
D. Proposal and negotiation of new statements embodying compromise, co-construction	[PhIII/D]
E. Proposal of integrating or accommodating metaphors or analogies	[PhIII/E]

PHASE IV: TESTING AND MODIFICATION OF PROPOSED SYNTHESIS OR CO-CONSTRUCTION

A. Testing the proposed synthesis against "received fact" as shared by the participants and/or their culture	[PhIV/A]
B. Testing against existing cognitive schema	[PhIV/B]
C. Testing against personal experience	[PhIV/C]
D. Testing against formal data collected	[PhIV/D]
E. Testing against contradictory testimony in the literature	[PhIV/E]

PHASE V: AGREEMENT STATEMENT(S)/APPLICATIONS OF NEWLY-CONSTRUCTED MEANING

A. Summarization of agreement(s)	[PhV/A]
B. Applications of new knowledge	[PhV/B]
C. Metacognitive statements by the participants illustrating their understanding that their knowledge or ways of thinking (cognitive schema) have changed as a result of the conference interaction	[PhV/C]

Figure 2. Interaction analysis model for examining social construction of knowledge in computer conferencing.

closely related to cognitive activity and in many instances were difficult to distinguish. We therefore described them as strategies in the co-creation of knowledge and negotiation of meaning and included them in Phase V.

Like Smith [17] who argued that Vygotsky's [16] distinction between lower and higher mental functions can be applied to a group's collaborative skills, we observed that as the group interacted together more effectively and learned from each other, the successive stages they went through could be considered forms of higher mental functions. The movement from lower to higher mental functions could also be observed in the arguments an individual contributor presented in a single message. The Interaction Analysis Model, therefore, begins with what could be described as lower mental functions: the sharing and comparing of information and moves through cognitive dissonance, to higher mental functions described in Phase III, Negotiation of Meaning and Co-construction of Knowledge, and Phases IV and V.

One could reasonably divide the social construction of Knowledge into more, or fewer, phases than described above. As noted above, it is also the case that all these steps do not always occur. In particular, where there is little conflict among the ideas held by the participants at the outset, negotiation tends to be largely unspoken; participants accept each others' statements or examples as consistent with what the group members already know or believe and the discussion may never advance out of phase one. It is also possible for conflict to occur and not reach the stage of resolution; participants may take away differing meanings, though perhaps arrived at or refined by the encounter.

Operations which we have placed in different stages of the process may actually occur at the same time. Different individuals, for example, may be proceeding at different rates through the processes and may be giving inputs which belong to a stage through which most participants have already passed. It is also possible to find messages which straddle the divisions between phases, including within a single message, units of learning which could be assigned to different phases. However, we believe the same objections could be raised to any possible division; the outline in Figure 2 has at least the virtue of relative simplicity.

Another possible manifestation of learning, as described according to a constructivist paradigm, might be the modeling of cognitive or metacognitive strategies by some participants and the adoption of those strategies by others; the conference may function as an exercise in cognitive apprenticeship [22]. This type of learning may occur at any of the phases.

Let us return now to the metaphor of the patchwork quilt as described in Figure 1. The contributions of individual members are the pieces of the patchwork. "Interaction" is the process by which all the pieces are put together as the learning experience proceeds. The co-constructed knowledge then becomes the pattern which can be viewed in looking at the interaction as a whole. This knowledge, or pattern, exists regardless of how much or how little of it is

assimilated by the individual participants. At the end, each participant is likely to take away his or her own construction, the pattern of which reflects in greater or lesser detail the pattern established in the whole. The evaluator's task may be to detect the emergent pattern, the degree to which all the participants have contributed their own pieces at each stage of its construction, and the extent to which the participants report or demonstrate relevant learning.

THE INTERACTION ANALYSIS MODEL FOR EXAMINING SOCIAL CONSTRUCTION OF KNOWLEDGE APPLIED TO THE DEBATE

While the interaction analysis model for examining social construction of knowledge was developed using grounded theory principles [4] and evolved through content analysis of the debate transcript, it is also important to discuss how this model can be applied to the analysis of computer conferences. Therefore, this section elucidates with examples how the model is applied to the analysis of the same debate transcript.

One of the first tasks in the application of the model was to decide on a unit of analysis. As previous interaction analysis models have shown, this is no easy task. In the section titled Analysis Of The Debate Transcript Based On Previous Interaction Analysis Models, we have discussed the problems associated with breaking individual messages down into units of meaning as Henri [9] proposed. In the debate transcript, messages exhibited many arguments spanning the phases described in Figure 2 to support or refute the debate proposition. If a message was broken down into units of meaning and each unit analyzed separately, we would not be able to describe the process by which arguments were advanced, building upon each other to support or refute propositions and negotiate meaning. We therefore decided to use a message as a unit of analysis, which taken as a whole embodied a participant's cognitive activity and contribution to the construction of knowledge, and code each message according to the phases and operations described in Figure 2.

A coding sheet was developed based on the phases and operations described in Figure 2 (for example, the code [PhII/A] identified "Phase II: The Discovery and Exploration of Dissonance or Inconsistency," "Operation A: Identifying and Stating Areas of Disagreement"). Each message was marked according to the phase it represents, the type of cognitive activity performed by the participant (questioning, clarifying, negotiating, etc.), and, in the case of phases 2 through 4, the type of arguments advanced and the types of resources used to support these arguments. Frequencies were then calculated for each of the codes. This process may be done by making inscriptions on a printed copy of the transcript or by use of a word processor, or qualitative analysis software package, such as Ethnograph, Atlas/TI, or NUDIST.

In examining the pattern of activity in the week long debate by frequency counts of messages, it became evident that the greatest number of postings occurred between Days 2, 3, and 4. This coincided with the introduction of the negative proposition and the days assigned for the affirmative and negative rebuttal, the period of time any debate would be most active. On the last two days, days 5 and 6, assigned for the affirmative and negative restatements, there were very few postings and the debate drew to a close.

Participation in the debate tended to be broad, representing contributions from many individuals, rather than multiple contributions from the same individual (at most three messages), but it demonstrated the wide variety of resources available to participants for use in exploring their differences and negotiating new meanings. These resources included reports of personal experience, citations to relevant literature, and even brief reports of formal data collected by individual participants.

The purpose of the analysis, however, was to study the process by which the new pattern of knowledge is arrived at. The questions uppermost in our minds as we started the analysis were: Did the debate as a whole move through the phases described in Figure 2? Can we say that the social construction of knowledge occurred?

The messages were viewed in the order they were posted and coded with the Phases and Operations described in Figure 2. We reread the transcript with a mental ear ready to detect the shifts in tone which may mark a transition from one phase to another, and a preliminary division into phases was marked. The answer to the question: Can one see evidence that the discussion proceeded through at least the first three stages? may provide a preliminary judgment of the quality of the conference. In general, the more phases the conference illustrates, the more participants who are active at each phase, and the greater the variety of resources the participants call upon in the process of negotiation of meaning or construction of knowledge, the higher the quality of the conference. Analysis of the debate according to the phases in Figure 2 indicated that the majority of postings and the majority of references to resources in the entire debate occurred at Phases II and III, indicating fairly high quality as several participants were involved in exploration of dissonance or inconsistency and the negotiation of meaning and co-construction of knowledge.

In analyzing the progress of the entire debate through the phases, it was evident that the debate format influenced the process of co-construction by sometimes supporting and sometimes hindering the efforts made by participants to reach a synthesis, a Phase III operation. The debate format supported Phase I by soliciting agreement on propositions, and Phase II by introducing inconsistencies between statements, and helped to move the arguments to Phase III. What the debate format hindered was the desire of the participants to reach a compromise or a synthesis on the propositions at Phase III and above, as the debate leaders tried to keep the two sides apart.

Two major themes were observed. One was the progress of certain strands of argument from Phase I to Phase V which can be described as an exercise in the co-construction of knowledge, moving from lower to higher mental functions. The other was the evidence of more than one and sometimes three phases within a single message posted by one participant, which usually progressed in sequence through the phases, showing progress from lower to higher mental functions, which provided evidence of how individuals contributed toward the co-construction. We refer the reader to the debate format described in an earlier part of this article and the debate transcript archived in the World Wide Web as we discuss this analysis. In order to maintain the confidentiality of participants in this article, authors of postings are identified by initials only.

A majority of contributions that occurred during the initial stages of the debate were coded as Phase 1: Sharing/Comparing of Information. For instance:

> I agree with the "No interaction, No education" assertion. Because of the reasons L.G. said in her opening statement: . . . interaction encourages students to critically analyze course content for the purpose of constructing meaning, and then validate knowledge through discourse and action . . . [PhI/B]
>
> I think other reasons are:
> —While there is interaction students will besides critically analyze content also REMEMBER the content better . . .
> —While interacting, you will often hear some new information you didn't know before, so you're EXPANDING your knowledge base. [PhI/C]
>
> Another thing I think is important: The more expert the one you're interacting with is, the more you'll learn. That's why I think that learner-instructor interaction is better for learning than learner-learner interaction. [PhI/C] What if you're interacting with a student who knows less than you about the content? [PhI/D]
>
> I hope that you'll comment on this assertions I made. (posted by E.R.)

The above message, which was coded at Phase I, exemplified three types of operations/statements in this Phase, as seen in Figure 2. Its sole purpose was to support the affirmative argument by providing additional new examples that were not discussed in the debate leader's opening statement. The message concludes by asking the group to comment on these additional examples that were put forth for consideration in an effort to obtain group consensus on the new information. This is similar to the process of social negotiation in knowledge construction described earlier, wherein a participant tosses examples to the group for consideration and observes whether or not the group accepts it as an example of the category or whether pieces must be altered to make it fit. It is when it cannot be made to fit that negotiation must take place and we proceed to the social construction of new knowledge.

The following message cites theory and research to support the affirmative statement, but also tries to move the discussion from Phase I/C to Phase III/B, by trying to negotiate the relative weight to be assigned to the debate topic.

> In addition to learner-instructor interaction within the classroom, some mention should be made of the relationship between student attrition (dropout) and informal student-faculty interaction. Noted attrition expert Vincent Tinto (1987) felt that contact outside the classroom was paramount when he stated the frequency and perceived worth of interaction with faculty outside the classroom is the single strongest predictor of student voluntary departure (reference cited, p. 8). [PhI/C]
>
> If distance educators fail to include interaction opportunities outside of the classroom and course content, they will inevitably run into problems with student retention. Education obviously can't happen if there are no students. So perhaps the argument should be: "No Interaction, No Students, No Education." [PhIII/B] (posted by J.M.)

During the initial phase of the debate, a number of postings from participants included examples both from theory and from experience in support of either the affirmative or negative propositions and were coded as Phase I statements. While Phase I statements dominated, a few participants tried to move toward Phase III in order to negotiate meaning and propose new definitions and lines of discussion. The following post is an excellent example of two phases and several operations within one message. Posted early in the debate, it tried to highlight the problems with the definitions expressed by the debate leaders and tried to move the discussion to Phase III.

> I am not sure in which camp my comments fit. I think they are closer to G.K.'s position than L.G.'s. So, I waited until today!
>
> Intuitively, there is no doubt in my mind that "interaction," is a necessary ingredient in any educational transaction, including in distance education transaction [Ph1/B]. However, I think "interaction" is only one category of transaction. One of the reasons we have difficulty in dealing with the concept of interaction is perhaps we mean different forms of transactions by it. [PhII/A]. So, I suggest that we should spend some time in defining it, and then as G.K. implied, find empirical evidence for its application. [PhIII/A]
>
> One way of doing this is to see what are the different concepts that may fit under "interaction," or as I am suggesting "transaction." Here are some suggestions: . . .

> So, before I go too far in this list, let say that my point is that we work with complex concepts in building a theory of distance education. Interaction is one of these complex terms. Complexity can be analyzed to a certain extent by using the right tools. I have selected systems methodology to do so. [PhIII/A,E]
>
> In moving toward that direction, I suggest we talk of transaction, as suggested by Moore, and conceptualize interaction as one category of it. In that way we may complicate things, but I think it will be a complexity which will bring more clarity. [PhIII/D] (posted by F.S.)

The debate format introduced the opposition of viewpoints on the second day with the opening statement made by the leader of the Negative proposition. The interaction recorded in the transcript moved from Phase I to Phase II and showed evidence of conflict among ideas. The following message which expresses dissonance and appeals to the group to examine the issue further exemplifies the types of arguments that were made at this Phase.

> What I suspect colleagues are likely to be differing about here is not whether it is possible to learn without interaction but about whether non-interactive learning can be worthwhile (educational?) learning. Is that right? [PhII/A,B] (posted by D.R.)

A number of participants while expressing dissonance or inconsistency among ideas, tried to move the discussion to Phase III to negotiate meaning as quoted below:

> The original proposition underlying this debate was that interaction was essential to distance education. The research cited by L.G. in her opening statement, as well as the supporting testimony supplied by others, establishes well enough that interaction is a valuable enhancement to distance education. [PhI/B] But does this research and testimony establish that interaction is essential as the proposition contends. I think not. [PhII/A] To make this case it would be necessary to show, not merely that DE is better with interaction, but that it is severely defective without interaction. A compelling case for this latter point has not, I think, been made here.
>
> The point is more than just a logical one. If interaction is not crucial to effective distance education, but only a desirable enhancement (however valuable) then it must be judged in terms of its costs and benefits. [PhIII/D] (posted by B.B.)

Reports of personal experience occurred frequently as Phase Two arguments; participants described their personal experiences as present or former students in arguing for or against the need for interaction.

Interestingly enough, the debate format actually served to make later stages of co-construction more difficult: the participants tried on many occasions to move toward compromise, particularly by negotiating the meaning of the term, "interaction," and their efforts were rebuffed by the moderators' attempts to keep the sides of the debate clearly defined! The debate proceeded almost in spite of the moderators to phase three. Having fully expressed their differences, the debate participants began to explore common ground and possibilities for compromise (Phase III, especially operations of types C and D). One participant mentioned having several years' experience in face-to-face teaching and stated "These experiences have led me to the conclusion that the amount of interaction required for learning to take place is a highly individual matter . . .", thus implying that a variety of correct solutions were possible. The following quote below exemplifies how participants tried to negotiate meaning and move the debate to Phase III.

> To conclude this point: Shouldn't we see the forms of interaction specified at the start of this conference—with content material, with teachers, with learners—less as forms of interaction per se than as different means for facilitating true reflective interaction in the learner? [PhIII/D] (posted by C.O'H.)

The difficulty posed by the debate format when trying to move toward a synthesis phase is discussed by a participant as follows:

> It is perhaps unfortunate that the format for this discussion is a formal debate. This means that we are not really discussing the pros and cons of interaction per se—we are debating the statement 'No interaction, no education'.
>
> It seems to me that both sides are saying: interaction improves the learning experience, makes it deeper, makes it more fun, makes it more memorable. But the "negative team" feel this is a nice-to-have, not a have-to-have. And the "affirmative team" is starting to agree!
>
> "So there is no doubt people can learn without interaction" (M.R.) and "Independent learning certainly takes place all the time" (C.L.) and so on.
>
> In this context, I can only agree with all those who are promising a changed statement for the debate—"No interaction, no education" puts the "affirmative team" in too tight a corner. [PhIII/D] (posted by S.A.)

While the predominant number of postings in the debate occurred at Phase II and Phase III, there were a few strands of argument that moved the discussion from Phase III, to Phases IV and V, in spite of the debate leaders' efforts to keep the participants from reaching a synthesis. One of these strands of argument is discussed in detail below.

> C.O'H. and A.A. addressed FEEDBACK under the negative. Yet, I feel they addressed the affirmative as feedback is interactive. [PhII/A] I agree that F2F is limited in the reflection required for higher order thinking. Asynchronous interaction with fellow learners and instructors allows us this reflection time. [PhI/B] C.O'H. asks about dynamic interactive multimedia as a feedback mechanism. This brings to mind Alan Turing's test for computer intelligence—can a user distinguish between a computer's and a human being's response to a question? He addressed this before computer interaction was widespread. It is a viable question today. If we capture "our" expertise in a computer program or simulation (as suggested by a recent contributor whose message I lost), are we not humanly interacting? [PhIII/D] (posted by M.L.)

The previous post moves the discussion through Phases I and II to Phase III to suggest a new proposition for consideration which has emerged as a co-construction stimulated by prior discussion and interaction on "feedback" and "dynamic interactive multimedia as a feedback mechanism." The new proposition asks the group to consider if we are not humanly interacting if we capture our expertise in a computer program [PhIII/D]. Elaborating on this line of thought, the message below posted by the leader of the Negative side (G.K.), moves the discussion through Phase IV to Phase V. This message first elaborates on the new concept proposed by M.L., tests it against existing cognitive schema and personal experience [PhIV/B,C], then summarizes the prior discussion and concurs agreement with the newly constructed meaning [PhV/A].

> I just want to elaborate on one new idea raised by M.L.—interaction doesn't have to be with a human. Intelligent tutors can provide feedback . . . and so can response forms in WWW. [PhIII/D] More generally, I think what people want is some kind of response from the system . . . so what we really need to worry about is that our distance ed courses/programs are responsive rather than interactive. I mean this is in the most general response: response on assignments, administrative problems, anything . . . [PhIV/B,C]
>
> To summarize this rebuttal . . . I think the preceding discussion indicates that it is not interaction that matters but responsiveness. [PhV/A] (posted by G.K.)

Carrying this strand of argument further, the following message supports the new construction of meaning arrived at by the negative side of the debate: "it is not interaction that matters, but responsiveness." The message begins at Phase V voicing agreement on the new concept of "responsiveness," and goes back to Phase III/D to negotiate the inclusion of "activity" as an important concept alongside "responsiveness." Then, the modified statement is tested by moving through Phase IV/B,C and agreement is voiced again on the importance of the newly constructed meaning [PhV/A]. This process exemplifies the social construction of knowledge in a constructivist learning environment where the newly constructed meaning is modified to fit with the individual's existing cognitive schema and then tested again before arriving at a conclusion.

> I am disappointed that there has been no response, pro or con, to G.K.'s significant statement that "it is not interaction that matters but responsiveness." I think this is important because the "positive" school has sought to include just about every possible exchange between teacher and learner as an interaction—including "feedback," . . . They have tried to make responsiveness look like "interaction" . . . [PhV/A]
>
> Indeed, it may be better to stress ACTIVITY rather than interACTIVITY . . . [PhIII/D]. It is actually the ACTIVITY of the learner which we give feedback on, and that can include the ordering of concepts, testing internal coherence, experience, experiment etc. So "No activity, no learning" and NOT "No interactivity, no learning." [PhIV/B,C]
>
> And RESPONSIVENESS does not even imply people (teachers or other learners). A good book is "responsive"—it anticipates and responds to my "searchlight"—and when it doesn't respond, that is often equally suggestive!— . . . [PhIV/C]
>
> Responsiveness and activity I believe accommodates a much wider range of learning styles and learning facilitation that the interaction-positive lobby would suggest. And, most important keeps that focus on the learner and how he or she learns. Which might of course sometimes, but not necessarily, involve interpersonal interaction [PhV/A] (posted by C.O'H.)

The following message posted by A.A. in response to C.O'H.'s statement in the last paragraph posted above, is a good example of the process of social negotiation at work, as it takes the discussion back to Phase IV: Testing and modification of proposed synthesis or co-construction.

> On Fri, 9 Jun 1995, C.O'H. wrote: "Responsiveness and activity I believe accommodates a much wider range of learning styles and learning facilitation . . . but not necessarily, involve interpersonal interaction" Next question will be: what will promote "activity" or "responsiveness"? Interaction? [PhIV/A,B] (posted by A.A.)

The co-construction of knowledge through social negotiation that happens in CMC and evident in this debate is described well by one of the debate participants:

> Well in simplistic terms you expose your arguments to others (maybe in a part progressive way . . . an outline here, a paragraph there). This in turn allows others (peers and tutors) to react to your thoughts . . . you continue.

> Your mind changes . . . somebody makes it succinct . . . a piece of reading you haven't thought of . . . Well this seems to be CMC written large to me. (posted by T.M.O.)

Therefore, when answering our research question, whether appropriate interaction analysis techniques would provide the means to determine that knowledge construction occurred within a group by means of the exchanges among participants, we could say that the interaction analysis model developed in this article did enable us to do so. The Phase model allowed us to focus on the content of what was said; the meaning of the arguments posted by the participants and determine how they contributed to the co-construction of knowledge. The summaries posted at the end of each day of the debate by the "summarizers," while not quoted in this article and analyzed because of their length, provided an excellent summative synthesis of the day's arguments and showed the process of interaction and social negotiation among participants in the co-creation of knowledge.

It is striking that the debate exemplified all five of the phases which the authors believe are characteristic of a constructivist learning experience, given that the format laid out for the debate might have been expected to foster only phase two activity. This suggests that the impulse toward co-creation of knowledge and negotiation of meaning is an even stronger force in the process of interaction than the authors had anticipated.

The following message that occurred as one of the concluding statements of this debate, shows an attempt to reach a compromise between the affirmative and negative sides, and move the debate discussion to a new plane to consider issues that have not been addressed so far. Coded as a Phase V statement, the message stresses the importance of recognizing the contribution of interaction and then moves on to another level of discussion to articulate meaningful distinctions between different types of knowledge and the importance of interaction for each type.

> As I read through the remarkably thoughtful postings of this debate, I believe there is broad agreement that interaction is valuable and that its value is a function both of a particular student's needs and the dispositions, as well as a function of the type of learning aspired to. There are, however, several underlying areas of genuine difference, and if not as large as we might have thought at the outset, they are nonetheless significant. [PhV/A] I believe the following are among these:
>
> 1. The appeal to a constructivist theory of knowledge, according to which "knowledge is constructed through social negotiation" comes perilously close to proving the essential value of interaction by mere definition. Adopting the premise that interaction is essential to the construction of knowledge forecloses a key issue in advance . . .

> We would be better served to recognize the potential contribution of interaction and focus attention upon trying to articulate meaningful distinctions between different types of knowledge or learning and assess the importance of interaction (or specific types of interaction) to each. There are a number of pointers to such distinctions already implicit in this debate . . . [PhV/B] (posted by B.B.)

The second research question we sought to answer related to whether individual participants changed their understanding or created new personal constructions of knowledge as a result of interactions within the group. We referred to these as metacognitive statements. Metacognitive statements by participants indicating that their knowledge or ways of thinking have changed as a result of the interaction that occurred in the group appeared throughout the debate and are quoted below. Although coded as a Phase V/C operation, it is important to remember that they are strategies in the co-creation of knowledge and negotiation of meaning characteristic of a constructivist learning experience. The difficulty of trying to distinguish between cognitive and metacognitive statements was discussed earlier.

The following quotation may be viewed both as corroborating the authors' view of the crucial importance of interaction in the co-creation of knowledge, and as an example of Phase V/C. It is clearly a metacognitive statement reflecting the participant's recognition of new knowledge.

> In the past two days, you who are contributing to this conversation have made me stop and think about "interaction." I guess you'd call that "learning." Without your thoughts this would not have happened. I think this signifies the importance of "interaction" to learning. (posted by S.L.C.)

The following is an example of how previous contributions are integrated into thought processes expressed by a participant. This and the previous quote exemplifies the process of cognitive apprenticeship [19].

[Emphasis added in quote.]

> **Prior postings** here establish clearly that not every student necessarily benefits (from interaction), **while, as G.K. points out**, the costs can be more than at first appears. This is especially true considering the . . .
>
> It would appear **that most of the research cited in this discussion** focuses upon how students report feeling about the effect of interaction on the quality of their educational experience. **G.K.'s suggestion** that perception may be what's important here, **makes me think** that what would be most helpful is some good data on the actual use of alternative modes of interaction by students . . . None of which is to say that lots of interaction is not a good thing. Only that it is never free and perhaps not always worth the cost.

Thanks to S.A. at Napier, whose earlier posting stimulated this line of thought. (posted by B.B.)

The above discussion has highlighted the analysis of the debate from a professional development perspective where the objective was to determine the process of knowledge construction through social negotiation among a group of professionals. If, by contrast, the purpose of the evaluation was to view the performance of single individuals for the purposes of assessment in a course, one might group all the message slips for one individual together and observe how many of the phases can be viewed in his or her messages. That is, did he or she actively participate throughout the conference? How close to the end of the process did his or her comments appear? One might also study the types of cognitive operations demonstrated by that individual: how many different kinds of argument can he/she be observed to muster in the conference?

While the focus of this article has been on discussing the development and application of the Interaction Analysis Model to determine the social construction of knowledge, the authors feel that it is difficult to arrive at an adequate judgment of the quality of an online learning experience by the application of a single method. Participation analysis and participant reports of satisfaction can further enrich the information obtained from content analysis of debate transcripts. A more detailed description of the application to the debate of participation analysis and participant self-report analysis may be found in Gunawardena, Anderson, and Lowe [7].

The next section discusses the application of the Interaction Analysis model developed in this article to another computer conference conducted by Terry Anderson, a co-author of this article.

THE INTERACTION ANALYSIS MODEL FOR EXAMINING SOCIAL CONSTRUCTION OF KNOWLEDGE APPLIED TO ANOTHER CMC CONTEXT

Transcript analysis models and related investigative instruments are only useful to the extent that they assist participants and investigators in understanding the learning that takes place using CMC. The efficacy of the interaction analysis model described above to both document and illuminate the learning that occurs was tested in a second online forum. This forum operated over a three-week period and facilitated asynchronous interaction among twenty-five workplace training managers. The forum was focused on discussing the impact of teaching and learning technologies on work place learning and was professionally facilitated and supported by the Office of Learning Technologies of the Government of Canada. An evaluation of this forum is discussed in detail elsewhere [23] and consisted of interviews, an online survey, and transcript analysis. In this section we briefly overview the contribution of the transcript analysis model to this second evaluation.

The transcript analysis procedure consisted of reading each message and assigning it to one or more phases according to a scoring sheet developed from the model in Figure 2. The researchers did not feel comfortable with arbitrarily designating a single posting as the unique unit of analysis, so occasionally a message that contained two or more distinct ideas or comments were coded in two or more phases. The messages were coded independently by both researchers. Discrepancies were discussed, and a single coding was determined from these discussions.

The total numbers of incidents in each of the Phases of the model were as follows:

Phase I: Sharing/Comparing of Information — 191 postings
Phase II: Discovery of dissonance and inconsistency — 5 postings
Phase III: Negotiation of Meaning/Co-construction of knowledge — 4 postings
Phase IV: Testing and modification of proposed synthesis — 2 postings
Phase V: Agreement/application of newly constructed meaning — 4 postings

These initial results from the coding were very interesting and forced us to question both the validity of the instrument and its theoretical underpinnings. The predominance of messages at the first and second phases made us consider if the forum, which was perceived as a very valuable learning experience by the participants, had supported the construction of knowledge or if the instrument had failed to document that construction. After considerable thought, we concluded that in fact the instrument was accurately reflecting the knowledge construction that had taken place.

The interaction that was captured in the forum transcript was not unlike the type of informal interaction that takes place at breaks or during social activities at face-to-face conferences or professional development activities. The Forum moderator was not empowered to act as a "teacher" forcing students to probe deeply and to resolve contradictions and differences of viewpoints. Neither were the participants members of a work team to which either a consensus or product output was demanded. The online forum was a useful sharing of professional experience. The transcript analysis model showed us, however, that informal professional discourse, though often valuable, is not congruent with the active construction of new knowledge.

Further work with the model and instrument, especially with formal credit courses and online work teams, is both needed and ongoing. This second application of the model revealed that many types and degrees of learning can and do take place during online interaction and that the analysis model and resulting instrument help us understand these learning interactions.

CONCLUSION: APPLICABILITY AND USEFULNESS OF THE MODEL

The primary contribution of this study lies in the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. The chief advantages of the new model, we believe, are:

- Its definition of "interaction in a CMC context" as the vehicle for the co-construction of knowledge.
- Its focus on the overall pattern of knowledge construction that emerges from a conference.
- Its appropriateness for use in constructivist and collaborative, student-centered learning contexts.
- Its straightforwardness and simplicity of use.
- Its adaptability to different evaluation purposes.

In particular, the authors hope that the model will encourage further study of interaction as a gestalt and a new focus on the function of an entire conference as a process of knowledge creation, replacing the currently-prevailing tendency in conference analysis to focus on blocks of connected messages without regard to the larger pattern of which they form a part.

The authors believe that a system of analysis which examines the stages of knowledge co-creation leads to greater understanding of the experience of learning in a computer-mediated conference than a "threaded" system of analysis. We have all had the experience of sensing that a conference has entered into a new phase. The most familiar example of this is when a conference abruptly "dries up," as if all the participants have suddenly sensed that the conference has run its course. To select an analysis method based upon phases or stages of knowledge co-creation is, we believe, to recognize this shared experience in the context of the overall gestalt of conference interaction.

AREAS IN WHICH FURTHER STUDY IS NEEDED

The model of analysis presented in this article has so far been used only to evaluate professional development conferences which have been designed as constructivist learning experiences, and which joined learners of roughly-equal skill and knowledge. The authors feel that the model is probably also appropriate for evaluation of conferences which have a moderator of greater skill than most participants (as, for example, the teacher and pupils in a secondary school class) so long as the moderator in such a case is open to conceptualizing the learning process as joint construction of knowledge or negotiation of meaning. We are eager to see evidence of work in this direction in the near future.

Levin and colleagues propose as one method of analysis what they call "message flow analysis," which diagrams the relative concentration of messages at various points in the time span of a conference [1]. The greatest concentration of messages tends to occur starting at about one-fourth to one-third of the way through the conference. While Levin and colleagues propose a variety of explanations for this, such as growing comfort with the medium and the distribution of workload within a semester, we see a possibility that this may also reflect the greater activity likely in Phases II and III of a conference as seen in the analysis of the debate, or in Phases I and II as seen in the analysis of the conference designed for training managers. Further research needs to be conducted to understand this phenomenon.

The analysis of the debate using the newly developed interaction analysis model revealed that certain types of CMC formats may not be conducive to achieving synthesis on an issue. The debate format did hinder participants from arriving at a compromise or synthesis and then testing that synthesis (Phases III, IV, and V). The debate format was excellent for supporting Phase II arguments expressing cognitive dissonance or inconsistency among ideas. Therefore, it would be interesting to utilize this interaction analysis model to analyze different types of CMC formats to determine if they support or hinder the co-construction of knowledge through social negotiation.

We believe that the debate had positive effects in producing a shared understanding of the nature and importance of interaction in distance education, and as one participant concluded "I think the discussion has sensitized everyone to the many different meanings of the term "interaction" and also to the weak research base associated with the subject." The debate also stimulated a sense of international collegiality among educators who participated. We believe that similar applications of computer conferencing, designed according to a constructivist paradigm highlighting the social construction of knowledge, have great potential for the improvement of distance education practice in general. We hope that the interaction analysis model developed in this article contributes to the analysis of such applications.

Note: Quotations within the text not specifically attributed to named conference participants have been lightly paraphrased.

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