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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

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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.

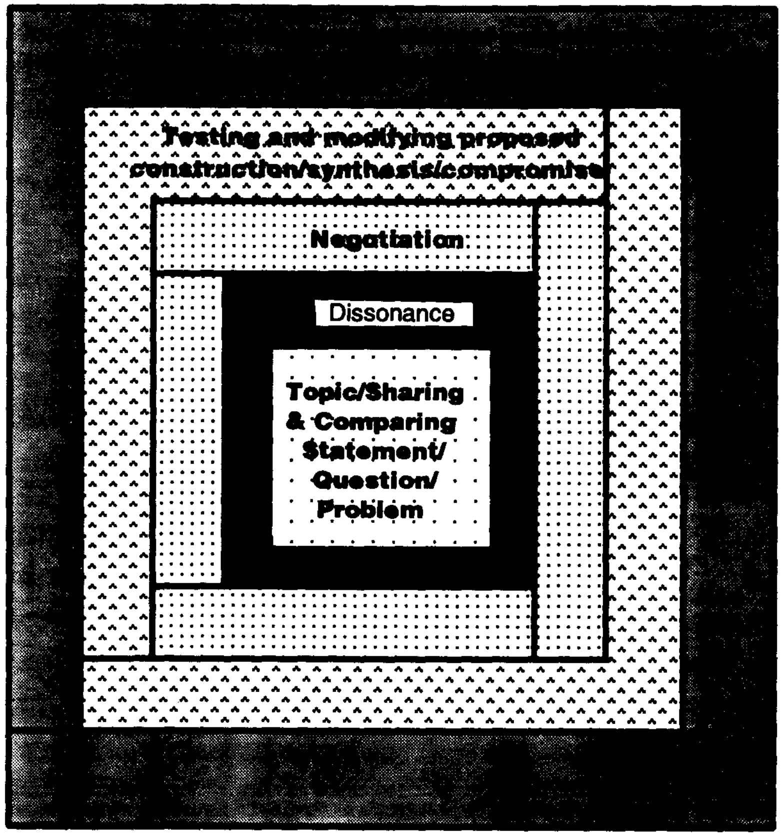
Roschelle [18] has noted that a unifying concept emerging from situated learning research (e.g., that of Brown, Collins, and Duguid [19]) is "communities of practice" where learning is seen as a construction of a social unit that shares a stake in a common situation. A community of practice arises through 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.



NOTE: Each piece represents contributions by one or more persons based on experience, research, theory, etc.

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