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Computer-mediated communication in higher education: an exploration of knowledge construction

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Computer-mediated communication in higher education: An exploration of knowledge construction

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Dedicated to my wife, Suheyla Saritas, and my son, Gokay Saritas.

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ABSTRACT

Constructivist theories about knowledge construction emphasize that knowledge construction is more powerful and meaningful when it is actively built up by students through engaging in equilibrated exchanges and experiencing cognitive disequilibrium. From this perspective, knowledge construction is thought to be effective in learning environments where intense interactive discussions can take place, deeply held values are shared, and complex issues examined from multiple perspectives (Harasim, 1990). Computer-mediated communication, more specifically computer conferencing systems (CCS), has captured the interest of educators as an ideal tool to create this type of learning environment, featuring active, participative, and reflective learning.

This study developed a conceptual framework, based on constructivist learning principles, to examine whether knowledge construction was promoted through computer conferencing in two graduate-level bioethics courses. Data collection focused on CCS transcripts, supplemented by student survey, instructor interviews, field notes, and course documentation. Knowledge construction through computer conferencing was examined from three main constructivist educational principles: 1) *active participation*—participation analysis was conducted to determine the nature of students' participation in the learning process, 2) *peer-to-peer interaction*—content analysis for interaction types, intermessage reference analysis, and message map analysis for interaction patterns were conducted, and 3) *cognitive conflict resolution*—content analysis based on Gunawardena et al. (1997) interaction analysis model framework was conducted to examine whether cognitive conflicts experienced in CCS promoted knowledge construction.

The findings of this study revealed that participation in the computer conferencing was moderate; interaction among students usually occurred through confirming or elaborating on the information/statement; and the predominance of computer conference transcripts reflected the first two phases of the knowledge construction process (i.e., sharing and comparing information, and exploration of dissonances among concepts and/or ideas).

The results of this study suggest that CCS by itself does not guarantee knowledge construction. The instructor's role in designing computer conferencing as a learning environment is crucial for fostering knowledge construction. This study provided insights into the nature of the knowledge construction process in a CCS environment and recommendations that help utilize computer conferencing technology in educational settings for students to construct knowledge more effectively.

CHAPTER I: INTRODUCTION

With the rapid evolution of information and communication technologies (ICT), our society continues to move forward into the "Information Age" (Drabier, 2003). Daily, we experience how emerging technologies change every aspect of our lives by affecting the way we communicate, manage information, use our time, and even complete simple daily tasks. Society, in particular, is experiencing information increasing at an inconceivable rate (Berge, 1995), which necessitates new skills, competencies, and knowledge in various fields that are required to become competitive and successful in coping with new tasks as they continue to rise (Owston, 1997).

Advancements in information and communication technologies are offering a promising new means in education to meet needs and demands of information age learners. ICT has the potential to provide a learning environment where students can actively be involved in the development of "initiative, creativity, and skills in critical thinking and problem-solving, mental and physical skills needed for productive work, using advanced technologies, engaging in group-processes, and developing good habits for self-direction and personal growth" (Kemp, 2006, p. 20).

Information and communication technologies have not only influenced basic communication patterns and knowledge interchange in education, but they also have offered opportunities to promote the processes of critical thinking and problem solving (Newman et al., 1997). One of the most essential educational benefits that ICT provides is its capacity to increase students' opportunities for collaboration and interaction. Some critics believe traditional distance education's inability to produce interactivity among participants in a learning environment can be effectively addressed through the features of innovative information and communication technologies. ICT offers the possibility of interactivity through which students can effectively manage varying viewpoints, evaluate alternative understandings and "adopt the perspective that is most useful, meaningful, or relevant to them in the particular context" (Bednar et al., 1992, p. 28). In particular, interactive discussions among students can be supported by these technologies, which lead to critical reflection, conflict resolution, and conceptual knowledge construction (Laurillard, 1993; Owston, 1997).

Computer-mediated communication (CMC) technologies, more specifically computer conferencing systems (CCS), may very well enable instructors and students to form a learning community, where intense interactive discussions can take place, deeply held values are shared, and complex issues are examined from multiple perspectives (Harasim, 1990). Students can participate equally without any coercion in this learning environment, where they can evaluate and compare various ideas and assumptions through negotiations of different meanings (Mezirow, 1991).

There is a growing interest by educators and psychologists in adapting and employing computer conferencing in their courses, either as an adjunct mode or as a primary full course mode because of the benefits it offers. For instance, computer conferencing offers a very engaging collaborative environment in which students can share views, experiences, and resources; diagnose misconceptions; challenge accepted beliefs; and construct new knowledge in a sense of shared community (Hammond, 1998). That is to say, CCS provides opportunities for students to construct knowledge and learn better by placing them in an intellectual environment that encourages active and reflective learning, divergent and critical thinking, interactivity and equal participation (Berge & Collins, 1995).

Purpose of the Study

Many educators and researchers claim that computer conferencing is an innovative educational tool that supports and promotes higher-order conceptual learning, analytical thinking skills, and knowledge creation (Curtis & Lawson, 2001; Kanuka & Anderson, 1998). The most recent literature on computer conferencing in education is especially replete with references to its potential to create a new learning context in which the knowledge construction process is well facilitated and promoted, compared to other educational settings (Garrison et al., 2001; Hara et al., 1998; Pena-Shaff, 2001).

However, there is little empirical research that supports these claims. Research on the use of computer conferencing in education has usually been restricted to the gathering of quantitative data (i.e., the frequency of student participation, number and length of messages, number of replies, message chains, and the level of interaction). In addition to this, some research studies tend to be too narrowly focused on the impact of computer conferencing on students' perceptions, attitudes, and satisfactions.

While there is value in these studies, they do not shed much light on the depth of exchanges between students and the knowledge construction process or the quality of learning that takes place in computer conferencing. These studies lack reflecting of the quality and extent of deep and meaningful approaches to knowledge construction fostered in a computer conferencing environment (Henri, 1992). Although, the amount of participation and interaction are important variables of knowledge construction, the quality of knowledge construction lies in the text-based communication, or in the content of messages, which demands coherent organization of thought, and clear, restrained, and authentic expression (Henri, 1992).

For the last few years, there have been an increasing number of studies that focus on evaluating the content of computer conference messages. However, first, most of these emerging studies relied on statistical information about general indicators of knowledge construction. Second, they lacked pedagogical principles, based on a theoretical framework in examining the notion of knowledge construction in a CCS environment.

This study, therefore, developed a conceptual framework based on constructivist learning principles of Piaget's (1970) epistemology to determine if students constructed knowledge while engaged in computer conferencing. This framework guided the entire study concerning three basic educational principles of knowledge construction: 1) students are active participants in constructing their own knowledge, 2) students construct understanding and knowledge better through equilibrated exchanges or peer-peer interactions, and 3) students construct knowledge through cognitive conflict resolution.

Unlike many previous studies, this study took a holistic approach to examining the knowledge construction process through interactive exchanges among students in a computer conferencing system. Thus, both quantitative and qualitative measures were utilized to investigate the evidence that students constructed knowledge while participating in online discussions via CCS and to identify the factors affecting the development of knowledge.

Research Questions

Three research questions, which were broken down into more operational questions as outlined in Chapter III –Methodology, helped address the purposes mentioned above. First, to determine the nature of students' participation, the question below was addressed:

Q1: Did using a Computer Conferencing System for group discussions foster active participation in the discussion activity? What was the degree and pattern of participation?

Second, to examine interaction patterns among course participants, the question below was addressed:

Q2: Did using a Computer Conferencing System promote interaction? What was the nature of that interaction?

Finally, to examine whether or not cognitive conflicts were experienced in online discussions that lead to knowledge construction, the question below was addressed:

Q3: Was there evidence that cognitive conflict occurs in a CCS environment? What was the nature of that conflict and how was it resolved in ways that reflect knowledge construction?

Significance of the Study

As the use of computer conferencing systems become more prevalent in society and constitute the primary means of information and communication in an education effort, educators need to become aware of how best to make use of this tool in the Information Age to effectively promote the knowledge construction process. This study aimed to provide insights into the nature and quality of the knowledge construction process in a CCS environment. In addition, this study provided educators and researchers with recommendations aimed at helping them integrate computer conferencing technology in educational settings for students to communicate and construct knowledge more effectively.

Assumption

The basic assumption driving this study was that the computer conferencing system promotes students' knowledge or meaning construction through interaction with their peers, and knowledge construction should be analyzed as a process rather than a product. Students develop their understanding through sharing and comparing ideas, information, and experiences through the attributes of CCS. Computer conferencing provides an opportunity for students to experience inconsistencies or dissonances among different ideas or perspectives. The attributes of computer conferencing help students actively participate and interact in online discussions for problem solving, interpreting and negotiating meanings, and conflict resolution. Thus, the interaction between students via CCS enhances individual cognitive growth and development, thus the knowledge construction process.

CHAPTER II: LITERATURE REVIEW

The literature reviewed in this chapter addresses two main areas. The first section focuses on epistemological paradigms to provide a background of how people acquire knowledge. Constructivism, as a theory of knowledge, is introduced to provide a foundation for the concept of knowledge construction. Then, socio-cultural constructivist theory, a trend of constructivism, is addressed to point out its primary approaches to the knowledge construction process that differentiates it from other constructivist theories. Next, Piaget's constructivist theory on knowledge construction is introduced and explained in detail as the theoretical framework for this study. From three basic educational implications of the Piagetian Theory, a conceptual model is developed to guide research design and methodology of this study. In addition, Gunawardena and her colleagues' Interaction Analysis Model (1997) for examining knowledge construction is adopted and reconceptualized, based on Piaget's theory. This model serves as the content analysis framework for the present study.

The second section of this chapter reviews pertinent Computer-Mediated Communication (CMC) literature, and, more specifically, the practice of computer conferencing systems (CCS), as a constructivist learning environment. The purpose of this section is to contribute to the literature on knowledge construction through participation, interaction, and knowledge construction processes as they relate to the special attributes of CCS. The advantages and disadvantages of specific attributes of CCS in educational settings will also be discussed. Finally, the findings of previous research on the use of computer conferencing systems in higher education are reviewed from three aspects—participation, interaction, and knowledge construction.

Part I: Theoretical Background for Knowledge Construction

Epistemological Approaches

The nature of knowledge and its foundation and scope, that is, epistemology, has been a multifaceted concept among scholars across the ages. Epistemologists have been typically concerned with such general questions as: “What is knowledge?” “What is the origin, or basis, of knowledge?” “How does one come to know?” “Can knowledge be certain?” Questions such as these have motivated the enterprise of epistemology from past to present.

In ancient Greece, numerous philosophers, specifically Plato (c. 427 – c. 347 B.C.) and Aristotle (384 – 322 B.C.), were occupied with philosophical questions about the nature, origin, and limits of human knowledge. Plato and Aristotle were concerned with the necessary conditions for a person having knowledge and with the issues pertaining to how one’s knowledge arises and how far it extends (Moser & vander Nat, 1987). In Plato’s view, knowledge is a justified true belief supported by reason or explanation. Knowledge is merely an awareness of absolute, universal Ideas or Forms. Plato endorsed the view that knowledge is only of what is unchangeable or the immutable (i.e., the Forms), and only what is immutable is real, and knowledge is only of what is real (Moser & vander Nat, 1987). Plato argued that knowledge of the Forms exists independent of any subject, which cannot be derived from sensory experience, but due to our prior existence, a priori knowledge of the immutable Forms.

Aristotle endorsed the Platonic assumption that knowledge is only of Forms, an apprehension of necessary and universal principles. However, although Aristotle’s Forms were immutable like Plato’s, they have different characteristic in that Aristotle’s Forms, which necessarily exist in physical objects, did not occupy a realm independent of the sensory world (Moser & vander Nat, 1987). Aristotle claimed that knowledge is always occasioned by sensory experience, where sensory perception, that is, the relation between perceiving and thinking of different kinds of sensory objects, and the role of the mind in perceptual knowledge, is focused (Moser & vander Nat, 1987). Thus, Aristotle put more emphasis on logical and empirical methods for gathering knowledge.

In the shadow of the epistemology of Plato and Aristotle, medieval epistemology was developed, based on orthodox Christian theology. The underlying assumption of medieval epistemology was that knowledge is inborn and comes from God. From this view, knowledge is related to cognitive soul, faith, and has its foundation in reality, or in the metaphysical (Moser & vander Nat, 1987). Philosophers of the middle ages were concerned with the issues of the relationship between matters of reason and matters of faith. They designed rational methods with faith into a unified system of beliefs to arrive at a reliable knowledge of nature, but many (e.g., Thomas Aquinas, 1225 - 1274) considered faith in scriptural authority as the core source of knowledge (Mendelson, 2000).

In the Age of Enlightenment (1600 to 1800), the efforts to discover 'how the world really is' became less important and the role of the sources of knowledge changed in which experimentation and observation became critically important (Losee, 1993). During this era, *rationalism* (knowledge as the product of rational reflection) and *empiricism* (knowledge as the product of sensory perception) dominated philosophy and became major sources of knowledge (Heylighen, 1993). The rationalists claim that people are "in possession of *innate ideas,* and that, being aware of their logical relationships, we [people] consequently have a priori knowledge, knowledge which the rationalists claim concerns the world *as it really is*.…The empiricists proposed instead that all our ideas have their origin in sensory experience, and that there is consequently no a priori knowledge of the world as it really is" (Moser & vander Nat, 1987, p. 107).

Until today, scholars have adopted different ways of responding to epistemological problems. They have been influenced by different aspects of the era and cultures in which they grew, and they made radically different assumptions about the nature of knowledge. The philosophical origins of the assumptions about these epistemological questions gathered under three broad paradigms—post-positivism, critical theory, and interpretivism.

The post-positivist paradigm (objectivism) assumes that knowledge is the universal discovery of facts and an internal representation of a real world that is structured, separate, and independent of the knower. Knowledge is thought to be fixed and "true" if it correctly reflects and mirrors this independent reality. In this view of knowledge, the accumulated truths in a subject area external to the knower can be transferred directly from one individual to another. From an educational standpoint, the goal of the learner is to internalize these truths and replicate the teacher's understanding and interpretation of the concepts. In this case, the more truths students absorb, the more knowledgeable they become.

Critical theory, like post-positivism, also claims that knowledge is external to the human mind. However, knowledge can be changed, based upon subjective-objective relations in certain situations founded on ideology and values (Carspecken, 1995). Critical theorists attempt to uncover local instances of universal power relationships (Comstock, 1982). Critical theory scrutinizes the cognitive processes related to learning which is not only reliant on what the instructor presents, but also on what the student does to process the new meaning or knowledge.

Interpretivism is opposed to the promises of post-positivism and critical theory that knowledge is external to the human mind. Interpretivists do not necessarily deny there is an external reality, physical reality, but are mainly concerned with the assertion that it is an "independently knowable" reality (Heshusius, & Ballard, 1996). Interpretivists claim that the structure of reality relies on experiences and perceptions. In this view, knowledge is constructed in a variety of contexts by individual interpretation of the world based on experiences and interactions with others (Denzin & Lincoln, 2000). While post-positivism seeks for universals and critical theory searches for local instances of universals, interpretivism looks for understanding of a particular context (Heshusius, & Ballard, 1996).

Constructivist Perspectives on Knowledge Construction

Constructivism, a theory of knowledge and learning, is based on the interpretivist paradigm. It rejects the positivist notion that all human knowledge reflects a "true" representation of independent ontological reality. Constructivism begins with a different set of assumptions about "knowing" and how one "comes to know." Rather than viewing knowledge as internalized truths or facts, constructivists believe that knowledge is constructed in human minds through personal experiences. Knowledge is constructed by developing unique idiosyncratic representations of external reality, based upon the person's unique experiences and knowledge construction processes. In other words, knowledge acquisition is a process of continuous construction through a cumulative series of interactions in authentic and meaningful contexts. Constructivism as a theory of knowing holds the following essential tenets as central:

1. Knowledge is not passively received either through the senses or by the way of communication. Knowledge is actively built up by the cognizing subject.

2. The function of cognition is adaptive, in the biological sense of the term, tending toward fit and viability.
3. Cognition serves the subject's organization of the experiential world, not the discovery of an objective ontological reality (von Glasersfeld, 1990).
4. Knowledge is constructed through social interaction. Social, cultural, and historical aspects are important variables of knowledge construction (Garrison, 1997; Larochelle, Bednarz, & Garrison, 1998; Gergen, 1995).

Constructivism is grounded in the learner's active role in the personal construction of his own models, concepts, and strategies through a concrete, contextually meaningful experience. Learning from this perspective is viewed as "a self-regulatory process of struggling with the conflict between existing personal models of the world and discrepant new insights, constructing new representations and models of reality as a human meaning-making venture with culturally developed tools and symbols, and further negotiating such meaning through cooperative social activity, discourse, and debate" (Fosnot, 1996, p. ix). Further, the learning environment is seen as a minisociety, a community of learners which entails opportunities and incentives to collect, record, and analyze data; examine and evaluate learning processes; reflect on previous understandings; and construct their own knowledge applicable to new and different situations (Crotty, 1994).

Constructivism is based on the fundamental assumption that learning is an interpretive, recursive, building process through which learners construct developmental and subjective knowledge by interacting actively within a physical and social world. Constructivism is not a unitary viewpoint. It has various trends, but constructivist theories are grounded to the same fundamental assumption and to the four basic principles of constructivism mentioned above.

However, the sociocultural constructivist perspective, as a trend of constructivism, is differentiated from others in terms of its viewpoint of the process of knowledge construction. Next, sociocultural constructivist theory is introduced. The socicultural constructivist perspective has gained increased attention among educators for the past fifteen years, along with the developments in information and communication technologies. It is believed that the fundamental concepts of this theory are essential to know —they have important educational implications from instructional strategies and practices to the role of teacher and students to the construction of knowledge.

Socio-cultural Constructivist Theory of Knowledge Construction

Sociocultural constructivists view knowledge construction as primarily a process of acculturation into an established community of practice (Minick, 1989). Sociocultural theory places its major emphasis on socially and culturally constructed knowledge, and rejects the notion of an individualistic-egocentric orientation of other constructivist theories that focus on knowledge construction as primarily a process of cognitive reorganization that continually develops and increases in sophistication and complexity.

Within the sociocultural perspective, "mind is regarded as the introjected social dimension" (Ernest, 1995, p. 481). A fundamental claim of this approach is that mental functioning is grounded in sociocultural settings. The theoretical foundation for the sociocultural perspective is inspired in large measure by the works of Lev Vygotsky. Vygotsky (1979) claimed that "the social dimension of consciousness is primary…. The individual dimension of consciousness is derivative and secondary" (p. 30). This is the key distinction between sociocultural constructivist theory and other constructivist theories. This claim can be interpreted in various ways, but its most descriptive formulation can be found in Vygotsky's (1981b) "general genetic law of cultural development":

> Any function in the child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane. First it appears between people as an interpsychological category, and then within the child as an intrapyschological category ... [I]t goes without saying that internalization transforms the process itself and changes its structure and functions. Social relations or relations among people genetically underlie all higher functions and their relationships (p. 163).

Sociocultural theorists, who adhere to Vygotsky's contention, tend to assume that cognitive (intrapsychological) processes are subsumed by social and cultural (interpsychological) processes. Bakhtin (1984) exemplifies this position by pointing out that, "truth is not to be found inside the head of an individual person, it is born between people collectively searching for truth, in the process of their dialogic interaction" (p. 110). In this perspective, knowledge, which is bound to a specific time and place, is a socially negotiated and constructed truth, resulting from co-participation in cultural practices.

There are, however, a number of concerns with these claims. One of the biggest criticisms relates to the evolution of higher cognitive functions (e.g., categorical perception, logical memory, abstract thought, and voluntary attention) from an intermental plane to an intramental plane. According to critics, this theory is inadequate to elucidate precisely how and why the transition occurs from the intermental plane to the intramental plane (Wertsch & Bivens, 1992). Many questions remained unanswered regarding the sociocultural circumstances under which transmission, internalization by Vygotskian terms, of cultural knowledge may take place.

A second concern with this theory is this social transmission process ignores the fact children possess a great deal of erroneous knowledge that could not be the result of internalization (DeVries, 2000). There is a pressing need to make conceptually clear the ways that transmitted knowledge is reorganized and/or changed in terms of social determinacy of human psychological functioning. A third concern, pointed out by Confrey (1995), is that Vygotsky's sociocultural theory does not preserve the independence of the natural and cultural developmental strands. Wertch (1985b) supports Confrey, who claims natural processes are only minimally represented by Vygotskians and there is virtually nothing that addresses the impacts of the changes in the natural line of development on cultural forces.

Sociocultural theorists defend their beliefs by emphasizing that it is improper to discern qualitative differences in individual thinking apart from their sociocultural settings, due to the fact that differences in learners' interpretations of scientific concepts and school-based learning tasks reflect qualitative differences in the communities in which they participate (Bredo & McDermott, 1992). Other constructivist theorists criticized this perspective by pointing out their views that qualitative differences in individual thinking exist. They believe that the quality of individual interpretive activity, with the development in the ways of knowing at a more micro-level, is a primary issue. They are typically concerned with an individual student's cognitive self-organization through the processes of interactive constitution of microlevel social situation (Cobb, Wood, & Yackel, 1993).

Whereas sociocultural theorists might view classroom interactions as an instantiation of the socially and culturally structured practices of schooling, other constructivist theorists would see a developing microsociety that does not exist apart from the classroom participants' efforts to coordinate their individual activities (Cobb, 1996). Furthermore, whereas sociocultural theorists focus on the social and cultural basis of personal experience and might perceive a student appropriating the teacher's contributions, the focus of other constructivist theorists is on the personal constitution of social and cultural processes, and actions of others in the course of ongoing negotiations.

Despite the differences between sociocultural and other constructivist theorists, there are a number of convergences that exist as well. For instance, children are commonly viewed as active in the construction of knowledge. The essential role of activity in learning and development is highlighted. However, activity, from the perspective of a sociocultural theorist, is typically linked to participation in culturally organized practices, social interaction.

Zone of Proximal Development (ZPD)

Sociocultural theorists claim that human mental abilities or cognitive processes are a product or creation of social interaction and social experience. The primary issue here is that individual-in-social-action or participation in social interactions affects higher psychological functions. For instance, Vygotsky advocates that a child is in no position of creating a conceptual world, but rather needs to appropriate the conceptual resources of the preexisting cultural world, which are passed on by his parents and other adults (Nicolopoulou, 1993). Vygotsky emphasizes that social matrices, in which children participate, have a crucial role in the development of higher psychological functions. These matrices are developed by the interconnection of two main systems—on the one hand, social systems such as family, school, market, and organizations, and, on the other hand, symbolic systems of a society that are culturally developed sign systems, such as the mechanisms to direct and regulate both social behavior and individual cognitive development.

From this perspective, the child learns within a social system from more knowledgeable peers and adults who transmit the cultural, ideal, and material heritage through a symbolic system. This perspective, which involves learning through social interaction with more knowledgeable or capable others in the 'zone of proximal development' (ZPD), is a central concept of sociocultural constructivist theory of cognitive development.

Vygotsky (1935/1978) defines ZPD as "the difference between the actual development level, as determined by independent problem solving, and the level of potential development, as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 86). The zone of proximal development is thus the difference between a child's autonomous activities (his actual unassisted performance on a task) and his potential developmental capacities (his performance in conjunction with outside support or guidance by more competent person).

In this concept, there is a strong relationship between the child's psychological functioning/construction of knowledge and preexisting systematic cultural understandings or cultural knowledge (e.g., teacher's mathematical knowledge). It is the knowledgeable person's responsibility to bring that culturally constituted knowledge to the child through accumulated cultural resources, including linguistic and other symbolic systems, and cognitive frameworks in structured tasks, so that the child may actualize his or her intellectual and developing capabilities. The child's world of activity, action-based experiences, and organization of thoughts are generally intended to be modified and aligned with the expert's or teacher's method.

The central focus of this subsection is not to provide a detailed description of sociocultural constructivist perspectives, but rather to identify fundamental beliefs or principles of it within constructivism. These principles provide insights into understanding theoretical concepts in the proceeding pages of this study.

The following subsection talks about another type of constructivism, *Piaget's Theory of Constructivism*, which is believed to present the most sophisticated and complete theory in education on the role of individual and social factors in knowledge development. Piagetian analysis of the conceptual development, emphasis on action and operation, and insight into the divergence of a child's thoughts from an adult's thoughts provide conceptual depth for understanding how knowledge construction occurs. Piaget's theory of constructivism constitutes the theoretical framework of the present study.

Piaget's Theory of Constructivism

The main body of Piaget's work centers on progressive logical structures through which the individual constructs knowledge. For this reason, Piaget is often presented as giving primacy to biological and individuocentric cognitive development. Sociocultural theorists have repeatedly critiqued Piaget for downplaying the social and cultural influences on cognitive processes. Furthermore, they have vociferously reacted against Piaget's individual, who is assumed to be a lonely scientist constructing knowledge apart from the social milieu.

This view is a generally held misconception and simplification of Piagetian theory. Piaget did not overlook the important role of social factors in the construction of knowledge.

For instance, in his work called *Genetic Logic and Sociology*, Piaget (1928/1995) remarked that "social life is a necessary condition for the development of logic" (p.120). In fact, he emphasized the co-equal role of the social world in the construction of knowledge, stating that:

> To wonder whether it is intrapersonal operations that engender interpersonal co-operations or vice versa is analogous to wondering what came first, the chicken or the egg. … The internal operations of the individual and the interpersonal coordination of points of view constitute a single and the same reality, at once intellectual and social (Piaget, 1977/1995, p. 294, 307).

Thus, for Piaget, the development of knowledge is far from being a unique tendency going from the individual mind to the external world. Rather, it is a conquest involving the simultaneous organization of intramental and intermental intellectual operations. He stated that it is impossible to identify the cause and effect in the process of the development of individual operations of intelligence and operations, making for exchanges in cognitive cooperation. Furthermore, Piaget pointed out that the general coordination of actions is both an interindividual and an intraindividual coordination, due to the fact that these actions can be collective as well as executed by individuals (1971). Piaget's view of individual and social factors on knowledge construction is the major difference from all other constructivist theories.

Piaget did not reduce the social to the individual. Rather, when speaking of knowledge construction, he gave great attention to social factors, and viewed individual operations of intelligence (process of active individual construction) and social cooperation among individuals (process of enculturation) as two inseparable aspects of the same system.

He described this system as a social "equilibrium" resulting from the interplay of the operations that enter into all cooperation (Piaget, 1970).

Piaget emphasizes the interaction of the individual with objects but also emphasizes the underlying importance of cooperative interaction with other persons. For Piaget, interaction with both objects and other persons provides rich and necessary contexts to construct cognitive systems—in other words, mental maps, schemes, or networked concepts (data structure): those underlying objects, situations, events, actions, and responses that grow in complexity as the individual gains more diverse experiences. According to Piaget, the process of the construction of cognitive systems, or structures, takes time and varies from person-to-person in terms of existing schemes or operations and subjective-objective experience. Piaget (1985) articulated this process in his model of constructivism, which has two related components: 1) constructivism as meaning making in a given context through the processes—assimilation and accommodation, and 2) constructivism as a change in cognitive systems overtime. Figure 1 below depicts the relationship between two components of Piaget's constructivism.

Application of Existing Cognitive Systems

The first step of meaning making or the knowledge construction process, according to Piaget, is the application of existing cognitive systems to new situations. Piaget describes two major cognitive systems, 1) *sensory-motor system* and 2) *operational system*. Both partially determine the level of achievement or intellectual capacity in any given situation. The sensory-motor cognitive system develops with reactions to immediately present events and stimuli from the environment. Through the sensory-motor system, the individual becomes able to coordinate complex cognitive maps, engaging in imitation of past events (Cowan, 1978), and to develop mutuality of expectation, intersubjectivity, and interaction. The important components of the sensory-motor system are internal coordinations of external, goal-directed behavior from concrete to abstract (De Lisi & Golbeck, 1999).

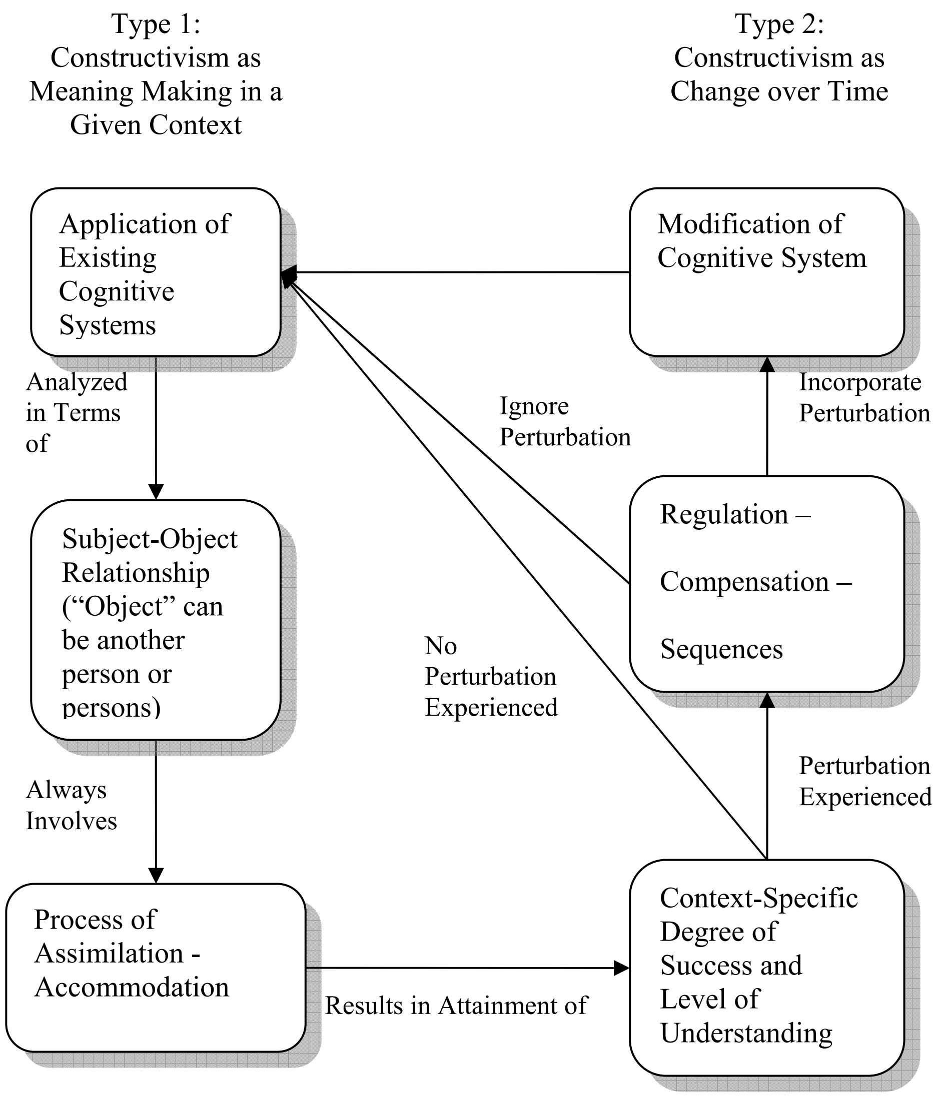


Figure 1. The relation between two types of constructivism in Piaget's theory (De Lisi & Golbeck, 1999, p. 6)

The operational system, on the other hand, develops from and includes the cognitive structures and abilities of the preceding system, sensory-motor system. In the operational system, the person's capability develops from mentally representing objects and events to acquiring semiotic functions (e.g., symbolic play and language games) to reasoning hypothetically and solving abstract problems in systematic and logical fashion. The components of an operational system are “internal coordinations of internal thinking actions that seek to attain understanding in both immediate and anticipated contexts” (De Lisi & Golbeck, 1999, p. 5). The operational system is distinguished from the sensory-motor system in that “thought-action scheme” or “thinking actions” are internally coordinated; whereas, “overt actions” are coordinated in the case of sensory-motor functioning.

The application of these cognitive systems is analyzed in terms of subject-object relationship. The object is any kind of source external to the subject. It can be either a tangible physical object (e.g., stone, toy, pencil, tree, etc.) or information in a textbook or the image on a website or another person or persons. Thus, the subject applies existing knowledge through interaction with these objects.

Subject-Object Relationship

Piaget considered knowledge and the functioning of cognition as a particular relationship between subject and object. Piaget’s notion of subject-object relations is founded on the dialectical nature of knowledge, which arises from reciprocal interactions between the subject and the object. Thus, knowledge does not involve the view of placing greater emphasis just on social experience nor that on individual cognition, but consists of the coordination of both. According to Piaget, the actions that the person performs with objects or on other people are a function of both the existing cognitive system and the specific context of incidence (De Lisi & Golbeck, 1999). Piaget depicted this subject (S)-object (O) interaction in cognitive functioning as $S \leftrightarrow O$.

Subject-object interaction is one of the fundamental concepts in Piaget's theory of constructivism, which describes knowledge construction by making new connections and systems of relationships with the objects (or persons) in the external world. The construction of knowledge in the subject-object relation comes from understanding the actions carried out on/with objects through two types of abstraction or cognitive reorganization, 1) empirical abstraction and 2) reflective abstraction.

Empirical abstraction results in the construction of the properties of the world (i.e., objects and events). Individuals constitute a set of specific groups or categories of properties or conceptual entities throughout their sensory-motor system within their environment. For instance, when a child abstracts color or shape from an object, she/he is ignoring all other properties of that object but color and shape. According to Steffe (1995), who regards abstraction as the lifeblood of constructivism, interactions of an individual with his or her environment as socially or physically are in the province of empirical abstraction.

In contrast to empirical abstraction where abstraction is from objects, in reflective abstraction, it is from the mental actions or operations of the individual. Reflective abstraction concerns patterns derived from the objective structures of action coordination and the logical structures of the reasoning. Von Glaserfeld (1995) emphasizes that in reflective abstraction, the cognitive subject establishes concepts based on the properties of the sensory-motor system, and elaborates these concepts into logical structures, and reorganizes them into more powerful and encompassing schemas. Henceforth, the subject does not only act on objects but also puts them into relationships, that is, constructs new conceptual structures within his/her operative or thinking system. One example provided by Confrey (1995) is "how the order of counting a set of pebbles evolves from actions; it does not lie in the stones themselves, but evolves from the counting action carried out on the stones." (p. 200). The concept abstracted from the activity of counting, *conservation of numbers*—Piagetian term, is not from the physical properties of the object but from the particular cognitive arrangements and co-ordinations of the subject as a result of reflective abstraction.

Von Glaserfeld (1995) points out that "reflective abstraction" produces a gradual replacement of exogenic knowledge by endogenic knowledge. As discussed above, the construction of knowledge, according to Piaget, is a constant interaction between endogenic and exogenic processes. In this interaction, "the products of empirical abstractions are always involved in reflective abstractions … [and] an empirical abstraction never comes into operation without there being prior reflective abstractions" (Steffe, p. 511).

Thus, empirical and reflective abstractions are the two sides of the same coin, which have an important impact on knowledge construction. Depending on the kind of abstraction an individual makes, Piaget argues that he or she develops three kinds of knowledge when acting on objects—physical knowledge, social knowledge, and logico-mathematical knowledge. Physical knowledge refers to knowledge of objects in external reality, which can be acquired through the perceptual properties of objects (e.g., shape, color, texture, density, and weight). For instance, a child obtains the physical knowledge materially and mentally by figuring out the reaction comes from a glass or a ball when dropped on the floor.

The second type of knowledge, social knowledge, is culture-specific, conventional arbitrary knowledge which is also external to the individual and can be obtained from actions on and interactions with objects or others. Some examples of social knowledge are written and spoken languages under certain circumstances (e.g., clock and watch), the fact that there are twelve months in a year, the symbols used to identify currencies, and the rules of behavior.

The third type of knowledge, logico-mathematical knowledge, is constructed within an individual's mind as an abstract knowledge by coordinating the patterns of ideas, relational structures, or networks of mental operations, in contrast to physical and social knowledge. The important notion is a system of relationships constructed in the head of the person. One would not know the difference and experience a cognitive change if he/she does not put the objects or meanings into a relationship

Piaget's concept of *conservation* is another example for logico-mathematical knowledge. Conservation (a logical deduction or reasoning) of numbers—for instance, the number "two" or "two oranges"—does not exist in external reality; and is not supplied by sensory-motor experience, but must be built through conceptual operative actions that comprise relating, coordinating, and/or abstracting.

As a result, logico-mathematical knowledge is constructed by each person through reflective abstraction; whereas, physical and social knowledge are built to a large extent by empirical abstraction from objects and/or persons in the outside world (Kamii, 1981). Because empirical and reflective abstractions are inextricably interwoven, neither physical knowledge nor social knowledge can be constructed outside a logico-mathematical framework and vice versa.

In sum, subject constructs an interrelated knowledge of physical, social, or logico-mathematical through interaction with objects by applying his or her existing cognitive systems in different situations. This construction of knowledge takes place through two types of cognitive processes—assimilation and accommodation. Piaget advocates that as people interact with their physical and social environments, they organize knowledge into groups of interrelated ideas, or schemes. People must assimilate new knowledge into an existing scheme in a cognitive system or they must create a new scheme to deal with it. He states that subject-object interaction always involves functions via assimilation and accommodation of knowledge. This concept is discussed in the following.

Processes of Assimilation-Accommodation

Assimilation occurs when the cognizing subject perceives new objects or events, based on existing schemes and/or operations. The subject attempts to apply his or her prior formed logical structures or understanding to the interpretation of sensory data to be able to incorporate new objects, events, or experiences into the existing functional cognitive system. In this process, new data and experiences could be incorporated into the cognitive structures, if they are consistent with the existing schemes and fit the needs. Hence, assimilation, a process that actively transforms the incorporated new sensory data and experiences, confers meaning in new circumstances.

New experiences, however, sometimes foster contradictions to the meanings we construct, making them insufficient and thus causing us to modify existing schemes to account for these experiences; thus, we accommodate old schemes to a new experience or object. In this sense, a*ccommodation,* comprised of reflective, integrative behavior in self-organization, typically results in the modification of existing structures to fit newly assimilated objects, events, and experiences in response to environmental demands and circumstances. However, accommodation still occurs if no modification is necessary. It occurs simultaneously in a quasi-automatic fashion with assimilation and influences subsequent assimilation and vice versa.

In this regard, Piaget (1985) described two postulates concerning assimilation-accommodation. The first one is: "Every assimilatory scheme tends to incorporate external elements that are compatible with it. This postulate provides nothing more than an impetus for seeking; it makes activity on the part of the child necessary" (p. 6). And, the second postulate is as follows: "Every assimilatory scheme has to be accommodated to the elements it assimilates, but the changes made to adapt it to an object's peculiarities must be effected with loss of continuity. This postulate indicates that modifying a scheme must destroy neither its closure as a cycle of interdependent processes nor its previous powers of assimilation" (p. 6).

Thus, in the interaction between subject and object, each process—assimilation (as the more stable generalizing side of intelligence) and accommodation (as the changing, discriminating side of intelligence)—accounts collectively for knowledge construction by creating more differentiated and integrated cognitive structures (Cowan, 1978). However, sometimes subjects may tend to either "over assimilate" or "over accommodate" in different situations. For instance, children's actions and concepts can sometimes be either overly subjective so they fail to account for the perspectives of peers and adults—over assimilation, or overly determined by outside forces including the perspectives of other persons so that they do not reflect their true ideas or abilities—over accommodation (De Lisi & Golbeck, 1999).

Symbolic play or fantasy is a good example where children assimilate more than they accommodate. They treat objects and actions as they wish by altering the world to serve their needs and fit their own inner meanings. On the other hand, there are some situations where accommodation preponderates over assimilation. For instance, imitation entails a greater degree of accommodation than assimilation because the child tries to copy another person's behavior. The child shapes and changes his/her actions to match the things he/she observes and perceives; thus, tending to resist giving response to external stimulation and to opportunities to impose his/her own actions or judgments on events in his/her environment.

Piaget claims there must be a balanced, self-regulation process (equilibrium) between assimilation and accommodation to compensate internal and external contradictions or disturbances to develop or construct more complex and integrated knowledge (Smock, 1981). Table 1 illustrates the functions of assimilation, accommodation, and equilibrium, based on a number of meaning-making behavioral forms. In the proceeding sections, equilibrium and disequilibrium, two salient concepts of Piagetian framework for knowledge construction, are discussed in terms of peer interaction and experiences, cognitive change, and modification of cognitive structures.

Table 1. Forms of Individual and Self-Other Meaning Making (De Lisi & Golbeck, 1999, p. 10)

Behavioral Forms	***Social Component***	***Function-Balance***
Fantasy play including daydreaming	Child is alone but typically represents self-other experiences	"Exercise" of previously developed understandings. Work on emotional conflicts. – *Assimilation.*
Parallel play	Child is in the company of another child who plays no role in child's play behavior. Play can reenact social experiences.	Same as above. Because other child is physically proximate, the potential to switch to an interactive form exists. – *Assimilation.*
"Look at what I can do!"	Child acknowledges other's presence and "uses" other person for self enactments.	Self verification via other demonstration. – *Assimilation.*

Table 1. (continued)

Behavioral Forms	***Social Component***	***Function-Balance***
Cooperative exchanges with another child	Child-other child are equal partners and therefore are free to agree and disagree with one another.	Co-construction of new understandings such as "genuine" reciprocity. Child and other are mutually engaged. – *Equilibrium*.
Peer regulation of child	Peer directs child's behavior but has to account for self's perspective and maintain attention.	Child is explicitly taught by another child based on mutual agreement or adult arrangement. – *Accommodation*.
Adult regulation of child	Adult directs child's behavior but has to account for child's perspective or get attention. Child is expected to obey directives.	Explicit teaching or behavior management by adult. Child learns about reciprocity by complement. – *Accommodation*.
Modeling	Other person determines child's behavior if child is motivated to attend, retain, perform, etc.	Child attempts to perform behaviors enacted by another in order to acquire new behavior, flatter other, pretend to be the other, etc. – *Accommodation*.
Delayed imitation	Child is alone but reenacts other's behavior including self-other relations.	Attempt to consolidate previous experiences. Work on emotional conflicts. Incorporate in fantasy routines. – *Accommodation*.

From Table 1, this study will especially focus on cooperative exchanges between students to determine whether or not knowledge construction has taken place in a computer conferencing environment. In addition, the conference messages of participants will be analyzed whether or not they reflect over-assimilation and over-accommodation behavioral forms as an interpretation of interaction and content analysis procedures.

Context-Specific Degree of Success & Level of Understanding

In Piaget's constructivist model (see Figure 1) assimilation and accommodation processes result in context-specific degrees of success and levels of understanding. A considerable amount of theory concerning the attainment of success in certain situations and that of understanding derives from the figurative and operative aspect of intellectual functioning in Piaget's framework. The function of figurative actions is to select, encode, store, and/or reproduce the knowledge of specific external events; whereas, operative actions coordinate and transform knowledge in a general conceptual structure.

Figurative actions are primarily accommodative—they repeat aspects of a specific circumstance and constitute the empirical world. On the other hand, operative actions (e.g., reversibility of a mental operation) are primarily assimilative—they relate, coordinate, and abstract the operations of the mind; that is, they construct the logical systems of transformations (conservation of invariants), based on the cognitive system's own logical operations, i.e., reflective abstraction (Smock, 1981). According to Piaget, conceptualization, understanding, and all forms of mathematical and logical reasoning require operative cognitive functions.

Therefore, figurative functions are important to attain context-specific success; whereas, operative functions (i.e., abstractions from coordinated actions) are important to attain understanding. In this view, a context-specific degree of success is dependent to our daily social experiences and interactions with other persons, and the level of conceptual understanding results from organization of those experiences and interactions (De Lisi & Golbeck, 1999).

Piaget (1995) attributes a fundamental role in knowledge construction to social exchanges or interactions, declaring that "the most remarkable aspect of the way in which human knowledge is built up … is that it has a collective as well as individual nature" (p. 359). Piaget (1965) associates two types of interaction, heteronomous and autonomous, or coercion (or constraint) and cooperation. Interactions or relationships between persons, according to Piaget (1965), can range on a continuum between coercion and cooperation.

The first type of interaction is one of coercion, where a child interacts with an adult of greater authority and accepts the ready-made truths, rules, or instructions provided by that authority. In this interaction, respect is unilateral (i.e., non-reciprocal and disequilibrated). The child is expected to remain egocentric and respect the adult or knowledgeable one's decisions or viewpoints without challenging them. This type of interaction is coercive and supports the idea that adults undoubtedly know more about almost everything so they regulate or control the child's behavior by keeping them occupied with learning, based on values, beliefs, ideas, and rules of others.

In this social context, children are prevented from employing their own interests, beliefs, and reasoning system, but rather tend to mindlessly confirm and rely on external regulations without questioning, analyzing, or examining their own convictions. A lack of mutual respect and reciprocity causes the child to not truly accept the logical necessity of the concepts given by the adult. For instance, when the teacher's idea is not understood, a child cannot conserve this idea, only he or she can approximate the observable form rather than the substance of the teacher's proposition (DeVries, 1997). Because there is no certain psychological equality in terms of the contribution of both participants to knowledge building, this interaction is not cooperative.

On the other hand, Piaget proposes a second type of interaction characterized by an equilibrated exchange between adult and child (i.e., mutual respect, reciprocity, and cooperation) in contrast to the heteronomous interaction. The adult respects the child's thoughts, beliefs, and thinking system, and provides opportunities for him or her to construct the system of understanding and regulate his or her behavior accordingly. Under conditions of equal power in interpersonal exchanges or mutual respect to each other's opinions, Piaget calls this type of interaction "autonomous" or "cooperative." Piaget (1965) stated that co-operation is a system of operations, a coordination of operations. Therefore, "the operations of co-operation are created by the exchange and not just by individual thought" (DeVries, 1997, p. 11).

Piaget also claimed that these cooperative actions (or equilibrated exchanges among individuals), in comparison to coercion relationships, have a superior affect in facilitating the cognitive restructuring necessary for knowledge construction. For Piaget (1965), such autonomous, cooperative actions occur most likely in peer interactions rather than adult-child interactions. Piaget emphasized the importance of equal power relations between peers, which allows for argument and subsequent cognitive development: "Criticism is born of discussion, and discussion is possible among equals: cooperation alone will therefore accomplish what intellectual constraint [unchallenging belief or value of others' knowledge] failed to bring about" (p. 409).

Following Piaget, De Lisi and Golbeck (1999) comment that cooperative peer interactions rather than unilateral adult-child interactions are essential to "counter the child's tendencies toward overly subjective assimilation and overly docile imitative accommodation" (p. 11). In order for a peer interaction to be successful, the principle of reciprocity, Piaget uses the term “equal footing” (Piaget, 1965, p. 61), should be maintained by the actions of the partners. Through equal footing, individuals interact by giving value and respect to the point of view of others, so that (social) equilibrium results in their interactions. This process, that is, conserving simultaneously more than one scale of value, act, or viewpoint, which Piaget termed “decentration,” could lead the child to examine and analyze different perspectives, and reconstruct his or her own views on the subject, thus affecting knowledge construction and learning.

In sum, according to Piaget’s theory, the context-specific degree of success and level of understanding is best achieved through equilibrated or peer-peer interactions. Through interactions with others, individuals might experience cognitive discrepancies or conflicts, which may lead to a cognitive change; in other words, the modification of cognitive systems and thus newly constructed knowledge. Next, this process is described.

Equilibration: From Perturbation-Regulation-Compensation Sequences to Modification of the Cognitive System

The notion of socio-cognitive acts such as viewing an issue from another’s perspective and thinking critically or analyzing it, based on own cognitive framework is widely recognized in the constructivist literature. For example, according to Fosnot (1996), different perspectives and new viewpoints on an issue foster conflicts with one’s understanding. Through these conflicts, however, the individual’s ability to think is facilitated and promoted. As suggested by Fosnot (1996), Piaget states that “new experiences sometimes foster contradictions to our present understandings, making them insufficient and thus perturbing and disequilibrating the [cognitive] structure” (p. 13).

Perturbation occurs, according to von Glaserfeld (1995), when the subject encounters a surprising outcome, an obstacle, or a lacuna. In other words, perturbation arises from the subject's own conceptual processes (von Glaserfeld, 1995), that is, from the subject's realization that something is incongruity, does not work, is harmful, or is an undesirable relation to his or her present cognitive system in a given situation. Thus, experienced perturbation may impel the cognitive system toward revision and change. In order to analyze how change occurs over time in cognitive systems (see Figure 1, right-hand side), Piaget proposed a process called *equilibration.*

De Lisi and Golbeck (1999) point out that Piaget's model of equilibration is based on three main forms (as depicted in Figure 2): 1) the individual components (schemes or operations) of cognitive system functioning via assimilation-accommodation as an ongoing (online) cognitive construction, 2) the interactions or restructuring of the relationships among schemes as a horizontal reorganization (i.e., subsystem cycle), and 3) the demarcation and the integration of the whole-knowledge structure; that is, a vertical restructuring between subsystems and the total system (totality cycle).

From this perspective, equilibration is a dynamic process by "its own intrinsic, self-organizing nature serves to keep the system in an open, flexible, growth-producing state" (Fosnot, 1996, p. 14), by generating perturbation-regulation-compensation sequences. It is perturbation-regulation-compensation sequences that lead, sooner or later, to a modification of cognitive system. Perturbation triggers this sequence, thus affecting cognitive change. If no perturbation (e.g., a conflicting, noxious thought or any lacuna or obstacle) is experienced, the cognitive system remains intact (see Figure 1).

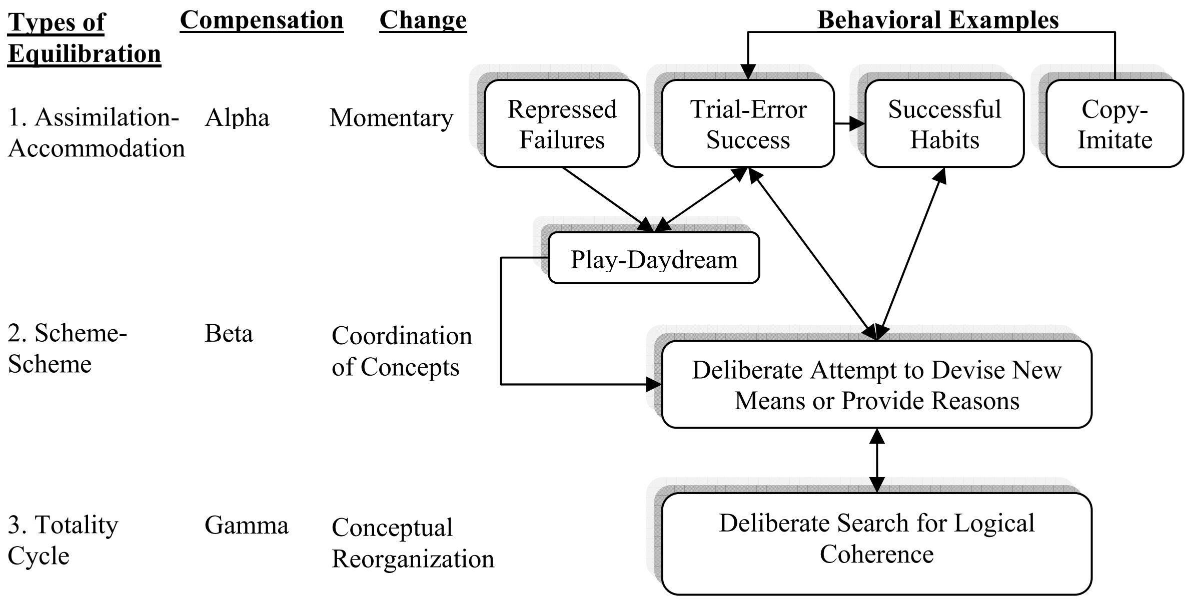


Figure 2. Three types of equilibration with behavioral examples (De Lisi & Golbeck, 1999, p. 16)

On the other hand, having experienced perturbation, the subject may or may not regulate his/her behavior. Either the subject simply may ignore the perturbation and repeat the previously experienced action without making any changes or the person may seek adjustments to regulate his or her behavior to deal with the cognitive failures or contradictions in order to attain a goal. Regulations of one's behavior lead to three types of compensations, which make possible a cognitive system to deal with such disturbances (see Figure 2).

The first regulatory compensation is *alpha*, where the regulation of perturbations functions as a quasi-automatic momentary fashion via the processes of assimilation-accommodation and leaves the whole system unchanged. The second is *beta* compensation in which the subject deals simultaneously with both an initial scheme or idea and perturbations, and finally the subject eliminates the perturbations by integrating them as internal variations. The third compensation is *gamma,* where a new, encompassing notion or anticipation of the possible variations that explain and resolve the prior perturbation is constructed. De Lisi and Golbeck (1999) describe Piaget's list including four characteristics about the functions of regulatory compensations on the modification of the cognitive system.

> First, every compensation acts against obstacles or gaps and at the same time draws useful information from these perturbations. Second, all compensations involve an evaluation of success and failure. Third, compensations tend to conserve states, sequences, schemes, or subsystems. Fourth, compensations are constructive in addition to being conservative. By acting against perturbations but drawing information from them, regulatory compensations gain in powers of anticipation, thus enriching the cognitive system (p. 18).

In conclusion, alpha and beta compensations represent the meaning making in a given context (see Figure 1); whereas, beta and gamma compensations represent horizontal and vertical reorganization (see Figure 2) (De Lisi & Golbeck, 1999). The succession of beta and gamma compensations leads to the modification of the cognitive system. Thus, beta and gamma compensations are essential elements in constructing new knowledge. The knowledge construction process never ends. It is a continuous, developing process in sophistication and complexity. Piaget's framework of knowledge construction is accepted by a majority of scholars as the most complete and structured model currently applied in various learning settings.

Educational Implications of Piaget's Theory

Piaget's constructivism has been widely recognized and accepted as a strong, orienting theoretical foundation in learning and teaching for decades. With the recent translations and interpretations of Piaget's epistemology, particularly of his sociological studies, (Fosnot, 1996; DeVries, 1997; Mays, 2000; Mays & Smith, 2001; Muller & Carpendale, 2000), it has gained even more popularity and value among educators.

DeVries (2000) listed a number of widely accepted educational beliefs based on Piagetian theory of constructivism as follows: a) children are viewed as active, that is, the child is active in the construction of knowledge, b) rote learning should be avoided, c) the language approach to teaching literacy is advocated, d) collaboration of children in instructional activities is advocated, and e) establishing a social atmosphere in learning environment is important, which provides a basis for children's co-operations or co-constructions.

Piaget's theory as a whole, however, is based on distinctive features with more complete and detailed explanations or descriptions (especially with regard to practical applications in education) than any other theory (Smith, 1996; Zimmerman, 1982). Since it is beyond the scope of this literature review to provide a full account of education based on Piaget's theory, the main principles will be summarized in the following.

There are three basic educational principles in which Piagetian theorists generally agree (Driscoll, 2000):

Principle 1: Learning and Understanding Are Active Processes So That the Learning Environment Should Support the Activity of the Individual. According to the Piagetian viewpoint, the activity of the learner is of paramount importance in constructing knowledge. In this view, knowledge is not simply imposed by external factors or forces; rather, the learner constructs knowledge actively by applying his or her most relevant concepts (i.e., prior knowledge) to encountered new situations. Thus, learning (or meaning making) is an active system of knowledge construction, where the concepts are invented rather than discovered: *to understand is to invent* (Piaget, 1973).

This viewpoint demands teachers design a learning environment in a way that allows learners to actively engage in the learning process and to articulate their newly acquired knowledge by creating cohesive explanations as well as interrelating semantic propositions or concepts. As Duckworth (1964) suggested,

> Good pedagogy must involve presenting the child with situations in which he himself experiments, in the broadest sense of the term—trying things out to see what happens, manipulating symbols, posing questions and seeking his own answers, reconciling what he finds one time with what he finds at another, comparing his findings with those of other children (p. 2).

The crucial point in this type of learning environment is that learners progressively develop complex cognitive structures. Therefore, from Piaget's notion of active learning, the objective of the teacher is not to teach, but to assist learners in developing knowledge and observe how participating in this activity can lead toward higher-order knowledge structure (Confrey, 1995). For Piaget (1970), active learning is not necessarily a physical, concrete activity that learners are engaged in, but rather is an authentic research activity which may take place "in the spheres of reflection, of the most advanced abstraction, and of verbal manipulations (provided they are spontaneous and not imposed on the child…)" (p. 68).

Principle 2: Cognitive Conflict and Equilibration – Adopt Instructional Strategies That Make Learners Aware of Conflicts and Inconsistencies in Their Thinking. Another principle that can be derived from Piaget's theory is cognitive development is promoted when there is a conflict or dissonance both within a learner and in viewpoints between learners. Piaget stressed that cognitive conflict promotes the equilibration process (Ginsburg, 1981). As discussed above, children must experience disequilibrium, or perturbation to assimilate new knowledge through conceptual change.

Piaget viewed conflict and its resolution as a part of the constructivist curriculum, where the teacher arranges situations that lead to contradictions (e.g., those arising from some limitation of the formerly constructed knowledge) and promote learners' autonomy in those conflict situations by orienting them via perspective taking and interpersonal understanding (DeVries & Zan, 1996). From this point of view, learners best acquire knowledge from experiences or instructional activities, which create cognitive conflicts or indicate inadequacies in learners' thinking. Conservation tasks that confront the inadequacy of learners' reasoning, as well as debates among learners or Socratic dialogue (Gruber & Voneche, 1995), are some instructional techniques for teachers to induce disequilibrated situations so that learners adopt more complex and adequate regulations for their cognitive development (Driscoll, 2000).

Two important pedagogical recommendations can be made about the second Piagetian principle. The first recommendation is diagnosing the knowledge that learners already possess and their methods of reasoning about a topic. This allows a teacher to know what questions are posed to create conflicts or inconsistencies in the current state of learners' knowledge and thinking (Driscoll, 2000). The second recommendation is taking into account the knowledge involved in an aspect of the curriculum as well as the interdependencies or interrelationships among units of knowledge. For instance, if it is mainly logico-mathematical knowledge involved in nature, then the teacher must plan instructional activities where learners can engage in reasoning and reflect on situations and problems that challenge their incorrect convictions or misconceptions (DeVries, 1997).

Principle 3: Learners' Interactions with Their Peers Are an Important Source of Cognitive Development, Thus Knowledge Construction. Perhaps the most central theoretical distinction of Piaget's theory with regard to education is the notion of cooperative interaction or peer interaction. What is unique in the Piagetian constructivist perspective is that equilibrated exchanges or peer interactions serve to promote learners' autonomous activities and construction of regulations, operations, and co-operations (DeVries, 1997). Piagetian theorists state that cooperative interactions are a must for optimal intellectual development. Thus, cultivating a feeling of community, where cooperative actions among learners are continually practiced, is an important constructivist strategy for teachers.

For example, perspective-taking actions and negotiation of meanings in conflict situations through small group exchanges help students produce a higher level of knowledge (Perret-Clermont, 1980). Children become more active participants in discussing dilemmas and searching logical coherence and scientific reasoning in symmetrical peer interactions rather than asymmetrical interactions (Perret-Clermont, 1980).

Piaget's concept of peer interaction is considered essential in educational settings for several reasons: a) peer collaboration and interaction serve to enhance student's socio-moral reasoning, b) change toward higher levels of reasoning is more likely to occur when discussion and dialogue are transactive in nature, c) peer-peer interactions are more likely to support such interactions than adult-peer relations, and d) classroom experiences supporting cooperation influence student's interactions with small groups so that children are more likely to demonstrate greater interpersonal competence and understanding (De Lisi & Golbeck, 1999).

Hence, social interactions such as discussions, dialogues, and negotiations in a reciprocal, mutual respect way are essential, in particular, for conflict resolution and conceptual change, thus cognitive advancement (Blatt & Kohlberg, 1975; De Lisi & Golbeck, 1999). To provide a learning environment where equilibrated, reciprocal interaction is encouraged, teachers need to "to become an equal and not a superior, to discuss and examine, rather than to agree and constrain morally…" (Piaget, 1995, p. 231). That is, teachers should minimize the unnecessary coercion, or unnecessary exercise of the authority by providing liberation of learners' possibilities for construction of their knowledge (DeVries & Zan).

It is obvious this type of educational philosophy is in contrast to that of Vygotskians—learners construct knowledge working with a more capable person where the ideal adult-child interaction is heteronomous, or disequilibrated. Creating learning environments where learners are given opportunities to "mutually express" their ideas; explore others' viewpoints and reflect on those; produce interventions through discussions or negotiations; and finally construct new knowledge from those negotiations is an important Piagetian constructivist characteristic of teaching.

Research Findings Related to Piaget's Constructivist Theory

The contributions and implications of Piaget's theory to education have been widely accepted and exercised by many educators, psychologists, and researchers. For example, Kruger (1992) conducted a study to explore the role of dyadic interaction through transactive discussions among 8-year-old girls on change in their level of reasoning about moral dilemmas. Research questions were designed to determine i) whether or not transactive discussions are related to change in moral reasoning, and if so, ii) whether or not peer interactions, as opposed to adult-child interactions, produce a greater cognitive change. Each student was assigned randomly to either a friend or her mother to discuss two moral dilemmas. For this study, pre- and post-test procedures were employed to analyze moral reasoning. The findings showed that students who were engaged in peer discussions developed higher levels of logical reasoning than those who engaged in adult-child interactions. This study showed results consistent with the hypothesis that equilibrated exchanges give rise to develop greater cognitive changes than adult-regulated or heteronomous exchanges.

Another study was conducted to investigate whether dyadic interactions that involve task-relevant disagreements and contradictions are more effective at fostering cognitive development than those interactions lacking these kinds of cognitive discrepancies or dissonances (Bearison, Magzamen, & Filardo, 1986). Children aged 5 to 7 were selected as subjects and assigned in groups of pairs to work together on a spatial-perspective taking task. An experimental design procedure was used to compare children who were in groups (experimental group) with the children who completed the task alone (control group). From videotapes of the interaction sequences of the experimental group, particular interaction strategies were analyzed. In these interactions, conflicts were differentiated as simple conflicting statements or gestures, and deep level logical contradictions. The findings revealed that while there was no significant difference between the experimental group and the control group in terms of their performance on the task, a number of significant traits of social interactions were found to promote cognitive growth.

Sociocognitive conflict among deaf children aged 5 to 13 was examined in another study (Peterson & Peterson, 1990). It was reported that deaf children were not as successful as hearing children in their skills of Piagetian operational actions and had a weaker drive toward cognitive equilibration because of adult- or parent-regulated strategies (e.g., overprotection or high tolerance). Therefore, this study focused on investigating whether or not deaf children, if working with peers in spatial perspective-taking tasks, develop cognitive gain in their logical reasoning. In such tasks, deaf children were engaged in enactive (i.e., relocating the object placed by another) and verbal disagreements actively and productively with one another. Based on pre-test and post-test results, the control group who worked alone did not produce a significant cognitive gain in reasoning; whereas, children, who benefited from working with peers and the sociocognitive conflict in peer debates, showed significant improvements in their operational systems. It was concluded that children, who initially and individually lack developing operational actions, can actually produce cognitive change and new knowledge through the process of co-construction of an understanding of the perspective-taking problems. These findings support the notion that peer interaction facilitates a modification of the existing cognitive system, thus the process of knowledge construction.

Furthermore, a study was conducted to examine knowledge construction among learners through peer interactions and online discussions (Gunawardena, Lowe, and Anderson, 1997). Researchers developed an "Interaction Analysis Model," based on grounded theory principles to critically examine the quality of interactions, the negotiation of meaning, and the co-construction of knowledge through discussions. Specifically, the following two research questions were addressed: 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?

To investigate these questions, Gunawardena and Lowe, with their graduate students, designed a debate as a constructivist learning experience among professionals who possess roughly equal skills and knowledge. The contentious topic—"the role and importance of interaction in effective distance education"—was chosen for discussion for knowledge construction and negotiation of meaning. However, as the debate progressed, this topic was reduced by the participants to "no interaction, no education."

The content analysis research technique was selected to analyze the transcripts of the debate by utilizing a coding sheet developed, based on the phases and operations in the Interaction Analysis Model (see Table 2). To answer the first research question, content analysis was used to focus on the content about what was said or the meaning of the arguments by the participants, and to determine how they contributed to the co-construction of knowledge. After analysis of the entire debate through the phases of the interaction analysis model, the results showed that the debate exemplified all five phases (see Table 2) defined as characteristics of a constructivist learning environment. Therefore, it was described that the progress of certain strands of argument from Phase I to Phase V is an exercise of the co-construction of knowledge. To answer the second research question, Phase V operations or strategies, especially, metacognitive statements by participants were investigated. The findings revealed evidence indicating that participants' knowledge or their ways of thinking changed as a result of social interactions throughout the debate.

However, the predominance of the contributions of participants in the debate was found at the first and second phases. That is, the debate format mostly supported the actions of sharing and comparing the information, soliciting agreement on propositions, and discovering dissonances or introducing inconsistencies between statements. In sum, these findings revealed evidence of the co-construction of knowledge and negotiation of meaning in the process of peer interaction. It was concluded that the debate format was an excellent educational tool, especially for supporting Phase II arguments to express cognitive dissonance and inconsistency among ideas (Gunawardena et al., 1997).

Gunawardena et al.'s (1997) Interaction Analysis Model is a useful tool to help understand and assess knowledge construction in different educational contexts. This model will be adapted for this dissertation study to conduct content analysis procedure to examine the knowledge construction process (see Chapter III: Research Methodology). Next, to provide a foundation, this model is further discussed from a theoretical perspective.

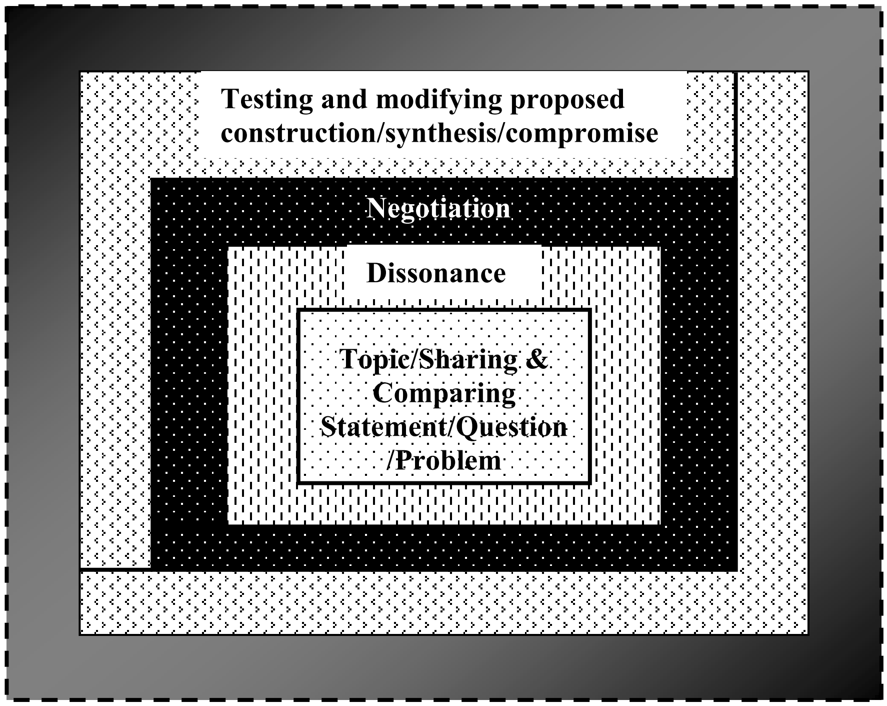
Interaction Analysis Model (IAM)

Gunawardena et al. (1997) stated that social interactions and negotiations, especially through a debate consisting of conflicting ideas, is a key feature of a constructivist learning environment. They emphasized the concept of 'interaction' as a collaborative construction of knowledge, a constructivist learning experience, rather than a one-way distribution of information from an authority or an expert to a group of learners. Gunawardena et al. (1997) found the past interpretations and definitions of the notion of 'interaction' as teacher-centered, mechanistic, and descriptive, where neither refers to the construction of knowledge. Therefore, Gunarwardena et al. (1997) redefined interaction as "the process through which negotiation of meaning and co-creation of knowledge occurs" (p. 407). They claimed that interaction is the totality of interconnected and mutually-responsive actions and statements; that is, the production of new knowledge or the understanding of new meaning (Gunawardena et al., 1997).

As shown in Figure 3, they illustrated their definition and understanding of the notion of *interaction*. Gunawardena et al. (1997) used the metaphor of a patchwork quilt block to describe the significance of interaction in producing new knowledge or arriving at new understandings of meaning.

Figure 3 below illustrates that "[t]he 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" (Gunawardena et al., 1997, p. 415-416).

Gunawardena et al. (1997) pointed out that newly-created knowledge or meaning, from this type of interaction, occurs at both the individual and social levels. Although they believed that the interdependence of individual and social construction of knowledge is important, the direction of knowledge development is generally viewed from the outside in (i.e., from social to individual). Considering this perspective, Gunawardena et al. (1997) supported Vygotskian ideas by stating that: "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" (p. 409). Being inspired by social constructivist theorists, they stress Vygotsky's notions of lower and higher mental functions to address the mental processes influenced by social factors.



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

Figure 3. A constructivist model of CMC interaction (Gunawardena et al., 1997, p. 411)

Specifically, Gunawardena et al. (1997), following Smith's (1994) argument, applied Vygotsky's distinction between lower and higher mental functions to a group's collaborative skills. They argued that the movement from lower to higher mental functions could be observed within both group interactions and individual contributions. They also advocated the idea that higher mental functions take place as the group goes through successive stages, interacts together more effectively, and learns from each other.

Based upon this theory, Gunawardena and her colleagues (1997) developed an Interaction Analysis Model (IAM) which consists of five phases of knowledge construction (as depicted broadly in Table 2): Phase I) Sharing/Comparing of Information; Phase II) Discovery & Exploration of Dissonance or Inconsistency among Ideas, Concepts, or Statements; Phase III) Negotiation of Meaning/Co-Construction of Knowledge; Phase IV) testing and modification of proposed synthesis or co-construction; and Phase V) agreement statement(s)/applications of newly-constructed meaning. In this model, they stated that it is not necessary for each phase to occur in sequence. For instance, a single message may support the affirmative statement, an operation of Phase I, by citing theory and research and may also move the discussion from Phase I to Phase III, by trying to negotiate the relative weight to be assigned to the discussion topic (Gunawardena et al., 1997).

Table 2. Interaction Analysis Model (Gunawardena et al., 1997)

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/or answering questions to classify 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 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/or 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 experiences, literature, formal data collected, or proposal of relevant metaphor or analogy to illustrate a point of view	[PhII/C]
PHASE III: NEGOTATION 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]

Table 2. (Continued)

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: AGGREEMENT 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]

Gunawardena et al. (1997) based Interaction Analysis Model (IAM) on constructivist conceptions of learning derived from shared constructions of knowledge. They quote Smith's notation of activity theory (associated with Vygotsky) by stating that "mental behavior is situated within the cultural and social contexts and is affected by those contexts" (p. 408). It is evident in their writings that Gunawardena et al. (1997) favored and supported the concepts of social-cultural theory by Vygotsky. Upon closer examination, however, a strong relationship and parallelism was found between the phases of IAM and the concepts of Piaget's constructivist theory (see Figure 1). In fact, IAM strongly reflects the theoretical framework of Piaget's constructivism as depicted in Figure 4 below.

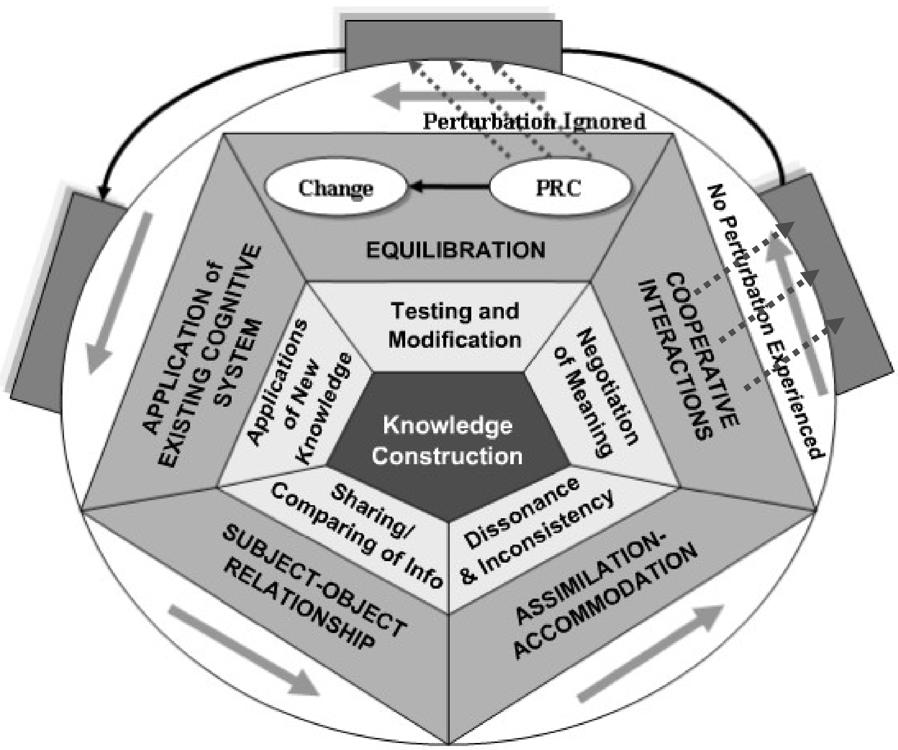


Figure 4. Pentagon Model: Parallelism between IAM and Piaget's Constructivism

The first phase of the interaction analysis model—*Sharing and Comparing of Information*—could be associated with Piaget's concept of S*ubject-Object Relationship,* where objects can be another person or persons. According to the subject-object relationship, the learner develops an understanding of objects and/or others from the actions he or she performs with and on them. Therefore, in Phase I, the subject is a learner who interacts with objects, that is, peers or information such as report, image, and resources provided by others. In this regard, the operations of Phase I, for instance, Operation E: definition, description, or identification of a problem, are two-way actions between learners to observe, consider, and compare the information.

After the initial phase of IAM, learners identify disagreements or conflicting viewpoints with the information provided by others (Phase II). That is, learners discover dissonance or inconsistency among shared and observed ideas, concepts, or statements incompatible with their existing framework of knowledge and thinking skills. Information must be altered to make it fit into a learner's cognitive system components for better understanding and knowledge construction. Therefore, there must be a balance or equilibrium between subjective and objective knowledge. This is very much consistent with Piaget's notions of assimilation and accommodation processes, which result in the attainment of success and understanding.

Having expressed dissonance, inconsistency, or difference, learners begin to explore common ground and possibilities for compromise through negotiation, or cooperative actions (Phase III). One of the Piaget's indispensable concepts—peer interaction, or equilibrated exchanges, in cognitive development—was well echoed in the third phase of IAM with the definition of '*interaction*' as the contributions of individual learners equally to the whole knowledge construction process (e.g., patchwork quilt block, see Figure3) with their own thoughts, experiences, and knowledge (e.g., texture). In addition, Gunawardena et al. (1997) adopted a learning context in such a manner that all participants, who are recruited from professionals (i.e., practicing specialists or advanced graduate students) in the same field, have roughly equal cognitive skills and levels of knowledge. Their model supported the idea that interaction taking place in a constructivist learning environment should consist of the dynamics of equal participants rather than the dynamics of a class led by a teacher. This is consistent with Piaget's theory that cooperative social exchanges in a way of mutual agreement and respect are crucial for controlling the operational system to attain understanding and knowledge construction.

However, having negotiated the meaning of terms or identified the areas of agreement or conflicting concepts alone is not enough for comprehension and knowledge creation. It is possible that learners over accommodate in Phase III and accept each other's ideas or examples without questioning or testing, which prevents them reaching advanced stages, that is, creating their own knowledge (see Figure 4). This is also consistent with Piaget's idea that perturbation may not be experienced in peer interactions.

From this point of view, Gunawardena et al. (1997) suggested that learners need to test agreed upon newly constructed meanings in Phase III against their existing cognitive schema and their respective experiences, and then '*perhaps'* (e.g., perturbations may be ignored, see Figure 4) modify them to fit in their cognitive structures (Phase IV). In other words, social exchanges result in a learning that actually requires learners to test and adjust their ways of thinking to accommodate new concepts or beliefs in conflict with their cognitive schema. This account of Phase IV of the interaction analysis model is in harmony with Piaget's concept—equilibration, as discussed in the preceding pages, modification of cognitive systems through perturbation-regulation-compensation (PRC) sequences.

Gunawardena et al. (1997) stated that modification of existing cognitive schema is followed by the application of newly constructed knowledge by learners in a given context (Phase V). It is through metacognitive statements or behaviors (e.g., reflection, evaluation, reasoning, and synthesis of the cognitive tasks) exhibited in these contexts that we can understand whether learners changed their understanding or constructed new knowledge as a result of cooperative interactions. Piaget's concepts of reflective abstractions, operative actions, and logico-mathematical knowledge are related to metacognitive behaviors. Piaget (1995) emphasized that the application of these behaviors is important to determine the level of success, understanding, and logical reasoning. Therefore, the application or exhibition of knowledge via metacognitive behaviors is in agreement with the first concept of Piaget's Type I Constructivism: application of existing cognitive systems (see Figure 1).

Consequently, by looking at each phase and analyzing Gunawardena et al.'s (1997) Interaction Analysis Framework as a whole, it was found to be consonant with the Piagetian constructivism. Based on this, educational implications of Piaget's theory are also valid for IAM. Hence, educational environments should be designed to promote active engagement and peer-interaction among students through the processes or activities that allow students to interact with each other, to ask questions, to formulate ideas, and to reflect on their actual knowledge as well as on what needs to be learned. In this sense, the role of the instructor is to design a curriculum that foster students' active participation and requires them to construct meaningful knowledge (Jonassen, 1992), by encouraging them to use multiple perspectives and knowledge representations so they can revise concepts and situations as their knowledge matures and enriches (Koschmann et al., 1996).

These pedagogical activities help students enhance coherence of their current understanding, evaluate existing knowledge structures by being sensitive to other frames of references, and synthesize/construct knowledge based on feedbacks/inputs from others or observations that may confirm or reject previous hypotheses. Learning is better facilitated through those instructional activities, which also provide opportunities for students to have responsibility and control of their own meaning making or knowledge construction process Jonassen (1992). Instructional activities should also encourage students to take a more active role through "self-reflection, goal setting, problem finding, problem solving and self-testing" (Koschmann et al., 1996, p.90).

Instructional activities such as aggressive inquiry, reasoning, and reflection in task-oriented, problem-solving situations are central issues in this type of constructivist learning environments. By actively engaging in these activities, students "become better able to evaluate knowledge claims and to explain and defend their points of view on controversial issues. The ability to make reflective judgments is the ultimate outcome [of these activities]…" (King & Kitchener, 1994, p. 13). The role of an instructor in this type of environment should be more of a facilitator or mentor in the construction of knowledge by supporting students to expose numerous perspectives and challenges to evaluate and develop arguments, and construct knowledge accordingly.

In summary, based on the literature reviewed on Piagetian constructivism, learning environments, which promote active participation, peer interaction, and cognitive change through conflicting viewpoints and reflection, have an important role on student's knowledge construction process. Many studies have shown that Computer-Mediated Communication (CMC) technologies, more specifically computer conferencing systems (CCS), support this constructivist approach to knowledge construction. Literature on the educational use of CCS shows a growing interest among educators and researchers in the special attributes of computer-mediated communication in terms of the context and tools they provide for meaningful learning environments.

The second part of this chapter focuses on the literature about CMC, particularly about computer conferencing, its attributes, and the past research conducted to evaluate the educational value of this medium.

Part II: Computer-Mediated Communication

Computer-Mediated Communication (CMC): A Brief Overview

As discussed in the theoretical foundation section of this chapter, "Piaget saw mental development as a dynamic process of disequilibration and re-equilibration, and continuous reconstruction of knowledge" (DeVries, 1997, p. 7). Therefore, from this constructivist viewpoint, learners are active participants in the learning process and knowledge is not delivered to them. Instead, they construct it by seeking to apply and understand concepts in situations where they can engage in dialogue and discussions, in a process of articulating thoughts and meaning through equilibrated exchanges (i.e., cooperative, autonomous interactions). In other words, students make learning meaningful and construct knowledge better in such learning environments where active learning, peer interaction, and cognitive dissonance or disequilibrium (i.e., three main educational principles of Piagetian constructivist paradigm) are encouraged.

According to the literature, in this type of environment, learners are more actively engaged in the process of learning (Duffy & Jonassen, 1992; Hannafin, 1992; Rieber, 1996), and enter into learning more purposefully and with greater motivation, as well as tend to retain and make use of what they learn better and longer (Knowles, 1975). Designing and maintaining such a learning environment is challenging for educators. However, with the advent of new technologies, it has now become more possible than ever before to overcome this challenge.

Computer network systems (CNS), for instance, are currently providing solutions and opportunities to create a unique learning environment featuring active, participative, and reflective learning. CNS provides a valuable alternative to the traditional modes of classroom (or face-to-face) and distance learning. One of the more recent revolutionary computer network systems (perhaps the most attractive and practical tool among those), that found an important place in education, is computer-mediated communication (CMC).

As Santoro (1995) explains, "at its narrowest, CMC refers to computer applications for direct human-to-human communication…. At its broadest, CMC can encompass virtually all computer uses" (p. 11). However, between these two extremes, CMC is referred to by many as a computer network tool for human communications, such as electronic mail (e-mail), interactive chat systems, electronic bulletin boards, and computer conferencing. More specifically, according to Harasim et al. (1995), CMC creates a learning context in which it is "meant for the sharing and building of ideas, information, and skills among the participants to strengthen knowledge building, integration, and application of conceptual information" (p. 24).

Currently, there are three modes of learning network activities in relation to computer-mediated communication widely used in postsecondary education—adjunct mode, mixed mode, and online mode (Harasim et al., 1995). The adjunct mode serves as a supplement to the traditional classroom. It retains the basic structure of the regular classroom and simply adds computer-based, out-of-class activities. The adjunct use of CMC allows students to communicate with the instructor and their peers outside the classroom. This provides students an opportunity to continue their learning process outside normal face-to-face (f2f) meetings by exchanging course-related information or assignments, and engaging in informal group tasks and discussions to extend their understanding and construction of knowledge on concepts presented in the class time. Although the adjunct mode is usually an optional strategy in instruction, this approach is currently the most prevalent form of CMC in higher education.

The Adjunct Mode

In the adjunct mode, for instance, the Internet can be integrated as a formal part of the course to allow students to connect with peers and experts in various specializations; or to require students to develop and investigate research by searching archival data, administering surveys, and interviews, all online. In addition, instructors can use e-mail and computer conferencing to distribute class outlines, complementary notes, handouts, assignments, assessment questions, and grades (Harasim et al., 1995).

To improve the learning experience, to foster greater peer interaction and collaborative work, and to create an active intervention strategy that ensures students are making progress in the course, The University of New Mexico redesigned one of its undergraduate courses, General Psychology, by integrating the adjunct (supplemental) mode of CMC into its traditional lecture style (Twigg, 2003). This new design was supplemented by interactive hybrid Internet/CD-ROM activities containing simulations and movies, online mastery quizzes, and programmed self-instruction offered on a 24/7 schedule (Twigg, 2003). Students are encouraged to take repeatable quizzes each week until they attain C-level mastery, which allows students to practice their knowledge as many times as needed to better perform on in-class exams. According to the evaluation results of this new structure of General Psychology, the number of students who received a C or higher grade increased from 60 to 76.5% and the retention rate of students also rose from 58% in the traditional format to 82% in the redesign (Twigg, 2003).

The Mixed Mode

The second mode is the mixed mode delivery of CMC. The key characteristic of the mixed mode is a reduction in face-to-face class meeting time, and replacing it with computer-based instructional learning activities. This mode is different from the adjunct mode because CMC is fully integrated and structured into the curriculum as a regular part of it. There are many variations and approaches of the mixed mode. For example, electronic case studies, computer-based role-playing, or simulation games provide a virtual environment for students to apply and comprehend better the theories and techniques learned in the classroom along with a rise in their interest and motivation in strategic and critical information. Another approach of mixed mode (i.e., the combination of traditional course and CMC) would be the use of online seminars in a face-to-face class to enable all students to have a voice and to see multiple perspectives on an issue, which is difficult in f2f classroom (Harasim et al., 1995). Moreover, the mixed mode can also be used for online seminars to encourage active engagement in devising and building arguments that foster cognitive change.

The redesigned course, General Chemistry, at the University of Wisconsin – Madison (UWM) exemplifies the mixed mode of CMC. A modularized, online system of diagnostic examples, tutorials, and quizzes were the techniques used to replace one of two lectures and one of two discussion sessions per week (Twigg, 2003). The purpose of this approach was to allow students to determine their existing knowledge and find what to learn to achieve mastery in a subject-matter. UWM designed thirty-seven web-based instructional modules. Each provides a debriefing section along with a series of questions that assess whether the student has mastered the content of that specific module (Twigg, 2003). This system not only provided students with feedback and direction for their learning in a subject-matter, but also increased opportunities for active learning and conceptual understanding.

The On-line Mode

The final mode of CMC is the online mode. Computer-mediated communication eliminates all in-class meetings and serves as the primary environment for course delivery through information presentations, discussions, assignments, and interactions among course participants. However, textbooks or reading packets, audio- or video-cassettes, telephone conversations, and face-to-face meetings for specific situations such as course orientation or final project presentations can be incorporated into the online mode.

The World Literature course at the University of Southern Mississippi exemplifies the online mode of CMC. This course was delivered through online computer technology to a single 800-student section (moved from 16 multiple lectures, including 65 students each) with 4-week instructional modules. This model reduced the number of full-time faculty as well as adjunct faculty to an only four faculty members as course coordinators, who used Web-delivered, media- and resource-enhanced presentations to teach their area of expertise within a specific module (Twigg, 2003). Course content, low-stakes mastery quizzes, individualized assistance, and different learning styles were embedded in the structure of the course that was administered via WebCT. Based on the course evaluation, more than 50% of students reported a positive impact of this new mode on their learning experience; and the number of students scoring C or better increased - from 61 to 77% in the area of writing skills—from 68 to 88% in the area of reading comprehension (The National Center of Academic Transformation, 2005).

It is evident that CMC has many variations that can be used in different modes. CMC functions can be discerned into three broad categories (Figure 5) in relation to "the nature of the human-computer interaction and the role taken by the computer in mediating the human communication process" (Santoro, 1995, p. 14).

The first category of CMC is *computer-assisted instruction (CAI), or computer-based instruction (CBI)*, which refers to computers as an instructor in providing interactive systemized and algorithmic instruction or tutorial along with computerized diagnosis and record keeping. In this category, the computer program takes a more active role in interactively presenting information and choices available to the student (Santoro, 1995).

The second category is *informatics*, in which the computer is programmed to store, retrieve, and maintain information to provide notifications, allow learners to take notes, and help them summarize content information. Online databases and online journals are some informatics applications. To given an example, autonomous agents, like Altavista Image, that contains a searchable index including millions of images, allow learners to search, evaluate, select, and interact with networked-based content. People's interaction with informatics has become a hot research area for scholars with recent developments in technology, such as eye tracking systems to develop more robust cognitive models about how people learn and develop new ways of learning.

The third category of CMC is *computer-based conferencing,* which takes three primary forms: 1) e-mail, 2) interactive messaging systems (i.e., Internet Relay Chat system or IRC), and 3) group conferencing systems (e.g., listserv, Bulletin Board System or BBS, and computer management systems) (Santoro, 1995). The main purpose of computer-based conferencing is to support direct human-human communication in literal and/or oral forms by "acting simply as a transaction router, or providing simple storage and retrieval functions" (Santoro, 1995, p. 14). A key characteristic of this category of CMC is that all participants have the opportunity to contribute to the interaction. Role play, discussion groups, brainstorming, case studies, project group, and the delphi technique are some instructional activities that can be utilized through computer-based conferencing.

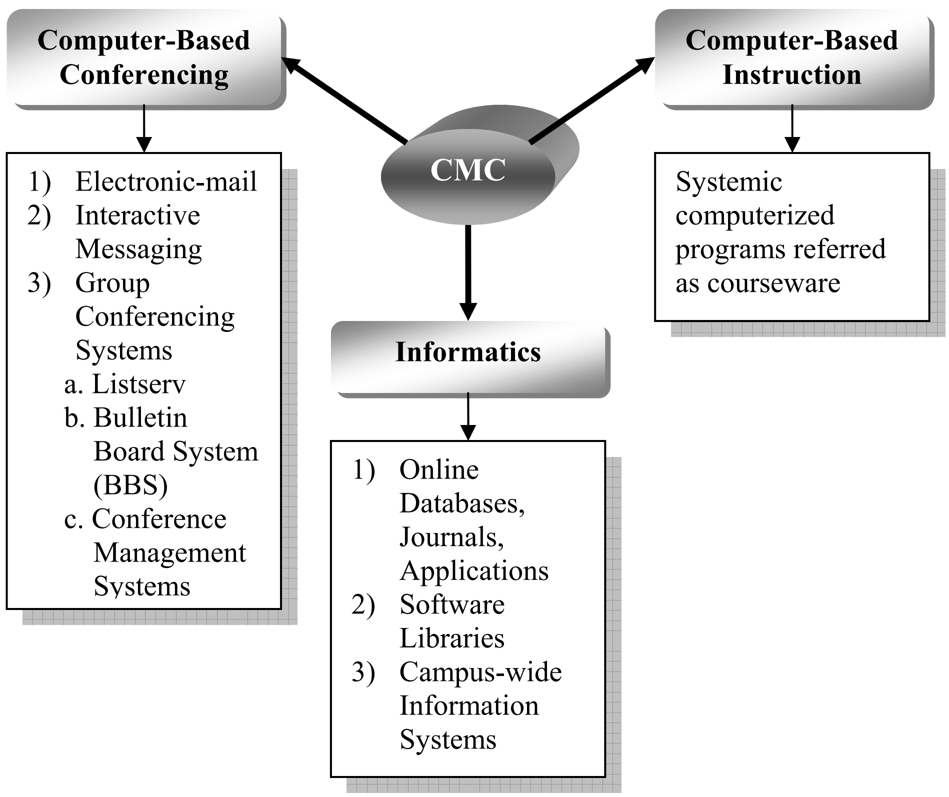


Figure 5. The Categories of Computer-Mediated Communication (CMC)

Computer-mediated communication increases our opportunities to communicate and interact with others, and expand the number of ways which may encourage cooperative, meaningful, and authentic learning activities relevant to learners' interests, needs, and goals through its various categories and modes of learning and teaching. The nature of the CMC applications and the way the instructor designs and conducts them has an influential role on the enjoyment of learning and the potential for the enhancement of cognitive skills. The applications of computer-mediated communication can be analyzed from two dimensions based on the extent they allow techniques from one-to-alone to many-to-many communication, and whether they provide s*ynchronous* (live, simultaneous, or real-time) or *asynchronous* (delayed) communication (see Figure 6).

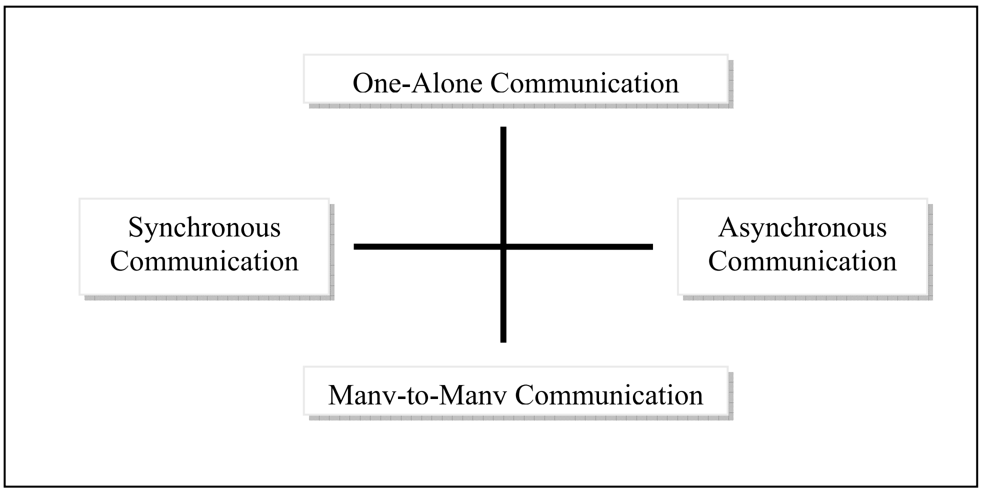


Figure 6. Computer-Mediated Communication (CMC) Dimensions

Some CMC systems provide one-alone communication, a simultaneous intellectual interaction of the learner with information from online resources without communication with the teacher and fellow classmates. Learners spend the majority of their time in almost all forms of education by interacting with educational information (e.g., textbooks, diagrams, hypertexts, and graphics). One-alone communication can also be defined as a learner-content interaction (Moore, 1986). In this regard, the outcome of a learner's cognitive interaction with the content may be an analysis or a personal reflective interpretation of the information.

In addition, some CMC systems provide one-to-one asynchronous communication; i.e., two persons can communicate with each other without time and space constraints. Electronic mail, or e-mail, is in no doubt one of the most commonly employed forms of this type of communication. In its most basic structure, electronic mail "involves a human computer user composing and sending an online ‘letter’ to another computer user. The recipient of this online ‘letter’ may then elect to read it, discard it, save it for later use, print it, reply to it, or send it to another computer user” (Santoro, 1995, p. 16). E-mail may also be used for one-to-many communication to communicate with multiple recipients via tools such as electronic mail exploder systems (an extension of e-mail), for instance, mailing lists and listserv programs. As depicted in Figure 5, listserv programs can be considered as a form of group conferencing systems, although they do not allow for many-to-many communication.

Many-to-many communication, which provides a shared space for group interactions and discussions, has the capability for learners to communicate either in the synchronous or the asynchronous mode. Synchronous communication requires that all (or most) learners be available simultaneously and the information exchange or interaction be time-sensitive. Synchronous CMC communication is also called *interactive messaging* because the flow of communication is similar to a telephone conversation (Santoro, 1995). The communication via interactive messaging can be either one-to-one or many-to-many, depending upon the computer program as well as the users’ preferences. Examples of synchronous CMC are Internet Relay Chat (IRC), that is text-based, and NetMeeting, which provides real-time audio and video communication.

Furthermore, many-to-many asynchronous computer-mediated communication provides a shared learning environment in which a community of learners can interact with “anytime, anywhere” convenience, flexibility, and accessibility. One example of asynchronous computer communication is computer bulletin board systems, or BBS. Bulletin board systems simulate the bulletin board at a shopping center or a company where people can place messages such as announcements, items for sale, and help wanted ads for others to see (Santoro, 1995). BBS are located either in intranet systems or the Internet, where users may post messages, read messages with an option to respond to the group or to an individual. Usenet NEWS and a wide range of newsgroups on the Internet are examples for this type of communication.

Another approach to asynchronous computer-mediated communication is what Santoro (1995) calls "conference management systems" (p. 19), or usually known as computer conferencing systems (CCS). In comparison to other CMC tools, computer conferencing supports a wider range of learning activities with a larger population and number of communications. The underlying concept of CCS is to create a virtual reality of a particular social system, where participants can organize and collaborate on a joint undertaking of the information or the material in a manner appropriate to their objectives and needs. CCS provides a structured approach through certain features of database management systems, in which the transcript of discussions are stored and specified in threads for allowing participants to isolate only the thread of interest and track the evolution of that thread. Moreover, some computer conferencing systems provide sophisticated information management tools, so the information can be edited or re-organized, depending on the user's preferences. Examples of computer conferencing systems include DEC VAXNotes, CoSy, Confer, and EIES.

One of the advantages of computer conferencing systems is they provide groups with specific spaces, wherein group work is facilitated and interactive participation, as well as interpersonal collaboration, is encouraged that can be tailored to the needs, expectations, and goals of the participants. Another advantage of CCS is that everyone participating is not judged, based on their gender, race, physical appearance, or status, but only on the value of their contributions. In fact, it is the special attributes of computer conferencing systems that give rise to those and many other advantages.

Due to its attributes, the use of CCS with emerging new technologies has substantially increased in the last decade. It has been recognized and considered as a powerful instructional medium that offers educators unique learning-teaching opportunities in various settings. Many higher education courses prefer to employ CCS for interaction and communication, either as a supplement method to their face-to-face lectures or as a primary course delivery medium. In addition to its support to interactive and collaborative communication, computer conferencing, among all CMC systems, is also used promote knowledge construction and meaning creation. To use the potential of computer conferencing systems, it is important to have a clear understanding of the attributes of computer conferencing described below.

Computer Conferencing Attributes

With the advancements in communication technology, particularly the Internet, the merging attributes and potential of computer-mediated communication have captured attention of educators and researchers to believe this technology may open new gates, and in fact, change the ways we communicate, think, and construct knowledge. In this regard, CMC and more specifically computer conferencing systems (CCS) have been recognized by their unique expression of both existing and new attributes that provide a special environment for teaching, learning, and knowledge construction alternatives to traditional distance and classroom education.

The uniqueness and potential of CCS lies beneath the concept that it shares and combines certain attributes of classroom and distance mode of teaching and learning (Harasim, 1990). For instance, computer conferencing is akin to distance education in that it is time-independent, place-independent, and mediated. However, in contrast to traditional distance education models, which are premised upon a one-to-many or a one-to-one mode of communication, CCS is similar to face-to-face education, since it supports interactive many-to-many communication, including the aspects and benefits of the social, affective, and cognitive peer interaction (Harasim, 1990).

Harasim (1990) describes five attributes that distinguish computer conferencing from existing types of education and that characterize it as a unique educational technology, providing a conceptual framework to guide design and implementation of learning networks. They are: 1) many-to-many communication (group communication), 2) place independence (any place), 3) time independence (any time, asynchronicity), 4) text-based (and increasingly multimedia), and 5) computer-mediated interaction.

Many-to-Many Communication

Until the advent of computer conferencing, the common interaction pattern in distance education, similar to typical face-to-face education, was based on one-to-many model of communication, or “IRE sequences” (Initiation, Response, and Evaluation) (Mehan, 1978; Wells, 1999). That is, the instructor initiates the discussion, then students reply, and then the instructor evaluates. Therefore, much of the discussion tended to be dominated by the instructor.

Unlike traditional distance education and f2f education, the potential of many-to-many communication in computer conferencing arranges information exchange and group interaction (Harasim, 1990). This provides an interactive and collaborative environment, where any student can initiate discussion or interaction; and participate actively by questioning, replying, or elaborating upon the information received, instead of acting as a passive recipient of information. From this perspective, computer conferencing supports active learning interactions or collaborations, which premised upon a learner-centered model that considers the learner as an active participant of a learning community.

In this type of community, the learner "actively constructs knowledge by formulating ideas into words, and these ideas/concepts are built upon through reactions and responses of others to the formulation" (Harasim, 1990, p. 43). Dewey (1916) described this formulation process as "getting outside of it, seeing it as another would see it, considering what points of contact it has with the life of another so that it may be got into such form that (the learner) can appreciate its meaning" (p. 5).

Anderson (2003) also noted that learners can achieve a deeper level of knowledge construction by engaging in many-to-many communication, or learner-learner interactions. Modern constructivist theorists support Anderson's claim and point out that group project work, and interactive participation and interpersonal collaboration among learners enhance the quality of learning and formulate a deeper understanding of the content. From this perspective, learners interact with peers to validate and challenge each other, which leads to critical reflection and the construction of knowledge (Anderson, 2003).

A substantial body of research suggests that peer interaction is a critical ingredient for effective learning and knowledge construction (Brookfield, 1986; Slavin, 1983). For instance, Stodolsky (1984) points out cooperative peer interactions facilitate greater cognitive development than the same learners achieve when working in isolation. Some responsible factors for this assumption are the multiple perspectives, critical reflections, and arguments (i.e., conceptual dissonance resolution and cognitive restructuring) that arise in cooperative interactions. Computer conferencing systems provide this type of context, a very engaging collaborative environment, in which students can share views, experiences, and resources; negotiate meanings; diagnose misconceptions; challenge ideas or beliefs; and construct new meanings or knowledge (Hammond, 1998, 1999).

In addition, many research studies identify computer conferencing as an educational tool that results in communication among learners, which is more equal in participation than found in face-to-face education. For example, Sproull and Kiesler (1991), conducted a meta-analysis of literature on published research on peer interactions They found that a group of people with different statuses, engaged in online discussions, shows about twice as much equality (in terms of participation frequency) as does the a group engaged in face-to-face discussions. Another study conducted by Huff and King (1988) revealed that proposals by graduate students were perpetually preferential during in-person discussion groups; whereas, proposals by both undergraduate and graduate students were selected equally as often in online discussion groups.

These data show the attribute of computer conferencing can provide equilibrated exchanges between learners. The data show also computer conferencing is a fertile forum for peer interactions to resolve cognitive conflicts, modify existing ideas, and finally construct new knowledge.

Place-Independent Communication

One of the most profound benefits that computer conferencing provides, as an alternative to f2f communication, is place-independent learning. This attribute of computer conferencing allows students to access learning and intellectual resources anywhere, regardless of their geographical location. It frees students of geographical constraints and expands access to a range of input that is richer and more diverse than what is available in a local traditional classroom (Harasim, 1990). The obvious advantage of this feature is there is no need to assemble everyone in a single location for learning or any kind of discussion. Learners have the opportunity not only to fully participate in online discussions with their classmates without place constraint, but also to interact and collaborate with academics, researchers, educators, and other learners on the basis of mutual interests.

Time-Independent Communication

Computer conferencing is also a time-dependent communication. Unlike time-specific traditional synchronous (real-time) classrooms, computer conferencing is based upon asynchronous (not real-time, delayed) communication. The asynchronicity of computer conferencing affords students the opportunity to read their classmates' postings, reflect on them, and formulate responses at a time and a pace convenient for them. It allows the learner to participate in in-depth discussions by checking references and resources, referring back to preceding topics and taking any amount of time to prepare a detailed comment or argument. This allows for an in-depth investigation and development of subject matter without time constraints.

Asynchronicity of CCS is becoming increasingly recognized as an innovative instructional medium that can be used as a supplement, as well as an alternative to traditional f2f teaching and learning. Wang (1993) compared dialogue journals conducted through e-mail with dialogue journals conducted in paper format in f2f meetings. The e-mail group was found to have written more per session, asked and answered more questions by using a greater variety of language functions, in-depth analysis, and critical reflection.

Another research study found that the average length of student postings in e-mail discussions was 106 words; whereas, in face-to-face discussion the average student answer was 12 words long (Quinn et al., 1983). In addition, students who are engaged online were found to spend 19 minutes on reading messages posted by others and 47 minutes on composing their own thoughts and contributions to group discussions. These findings support the idea that the asynchronicity feature of computer conferencing encourages students to critically reflect, analyze, and synthesize their thoughts, thus growing cognitively.

Time-independence is an important characteristic of CCS, which welcomes all participants to contribute whenever they are willing. There is no time restriction so that the dominance of communication by one or few learners that limits expression or opportunities to speak is eliminated. Learning and interactions can take place over a period of time (e.g., a discussion topic would last for several days, weeks, or even months). The records of these interactions or statements are stored in a database system, so this attribute provides flexibility to access previous learning materials and interactions at any time. It would be fascinating to see how different one's perspectives, interpretations, and reactions to the same exact record of postings by students could be when one rereads those at different times (Lynch, 2004).

Text-Based Communication

Another feature that distinguishes computer conferencing is the text-based form of communication. Although new emerging technologies allow for the inclusion of multimedia information, communication and interaction among students in CCS, in current practice, is mainly mediated by and conducted through text—that is, by sending and receiving messages typed into the computer system (Harasim, 1990).

Compared to traditional classroom interaction, reading and writing messages online give an increased opportunity for thinking about and reflecting on a topic en route to knowledge construction. This form of communication, or written discourse, is considered an essential tool for knowledge building and higher-order cognitive learning. Fulwiler (1987) supports this notion and strongly argues that, indeed, writing is often necessary when the objective is higher-order cognitive learning. Moreover, Harasim (1990) advocates that verbalizing the aspects of interaction within a text-based environment can augment metacognitive skills, such as self-reflection and revision in learning.

Through text-based communication, learners defend, prove, justify, and communicate their ideas to others by making thinking tangible, that is, by explicating and organizing their conceptions into more meaningful and coherent comments (Ahern, Peck, & Laycock, 1992), which promote the development and practice of metacognitive skills.

There is a large body of literature on reading and writing that have a crucial role on effective learning and knowledge (meaning) construction. For example, Spivey (1995) offers insight into how writing (composing) and reading (comprehending) can contribute to meaning construction. “A written text is merely a blueprint; it offers a set of cues— cues to meaning constructed mentally by the writer during composing, cues selected by the writer to suggest configurations of meaning to readers, and cues used by the readers in mentally constructing meanings of their own” (Spivey, 1995, p. 314).

In this sense, both writer (composer) and reader (comprehender) are constructive agents in constructing meaning for and from a text in various transformations and in reciprocal acts. Composers become comprehenders when building meaning for writing one text as they build meaning from reading another text; and comprehenders become composers when they are engaged in a process of providing response—producing their own texts in the form of questions, commentary, or rationale to support their judgments or opinions (Spivey, 1995). Therefore, writing and reading are both constructive processes which build meaning from each other's cues.

Computer-mediated Interaction

The fifth attribute of computer conferencing is computer-mediated learning on which the previous attributes explained above depend. For this reason, this is considered to be the most important attribute of computer conferencing. It is mainly the nature of this attribute that distinguishes computer conferencing from other forms of educational communication. Although some of the attributes above, such as text-based and time-independence, are available through other means, this attribute generates a unique set of capabilities for computer conferencing systems because it is interactive; it encourages active engagement; and above all, it gives learners control capabilities in presenting, receiving, processing, and managing information (Harasim, 1990; Kozma, 1987; Mason & Kaye, 1990; Rice, 1984).

In addition, with the function of this attribute, computer conferencing can maintain a written transcript of entire conference interactions by creating a shared space, record, or group memory stored in a database system. These records can be accessed asynchronously to revise and retrieve for later analysis or further educational purposes via search mechanisms. This feature of computer conferencing provides learners with the opportunity of selecting particular items to read, based on their needs, saving them to disk or printing them for later use, referring back to previous discussions for more intensive review and so on (Harasim, 1990). According to Harasim, this last attribute of computer conferencing deserves a particular attention in that "learner strategies such as weaving (synthesizing key themes in a conference) and critical reviews of the proceedings encourage multiple passes through the transcripts to enhance analytical thinking" (p. 52). Moreover, it activates and amplifies the learner's cognitive processes of obtaining, manipulating, interconnecting, and structuring information (Kozma, 1987; Scardamalia et al., 1989).

The Impact of the Attributes of CCS

The potential of computer conferencing, with different combinations of its attributes either for an adjunct, a mixed, or an online mode of learning and teaching, appears to offer unique learning activities and environments for knowledge construction and meaningful learning. These five key attributes frame computer conferencing environment and are recognized to support the constructivist approach to learning and teaching, and are thought to benefit the three main educational principles (explained above). These include 1) learning and understanding are operational, active processes so the learning environment should support the active engagement or participation in the learning process, 2) peer-to-peer interaction is an important source of cognitive development, and 3) cognitive conflict and equilibration are critical components in knowledge construction.

Computer conferencing environments have power that lies in their capabilities to encourage learners to be actively engaged in the process of knowledge construction. CCS has the tools needed to create a context supporting the shifting paradigm in education that learners are meta-cognitively (e.g., self-planning, self-monitoring, and self-evaluating) active and constructive in their learning process, rather than passive recipients of knowledge aroused by the instructor. Asynchronicity, for example, augments the possibilities for active intellectual participation and input: the online classroom, open 24 hours per day and 7 days a week, allows learners to participate in and contribute to discussions by taking their time to reflect or further research the topic. The learning process never stops. Asynchronicity enables learners to provide reflective and sophisticated statements by accessing learning contexts (e.g., discussion forums, online resources) at a time convenient for them, thus facilitating increased activity, increased participation, and involvement in what they learn.

Wiesenberg and Hutton (1996) reported that learners are more willing to participate and make comment in CCS than in a regular classroom setting. In computer conferencing, Harasim (1992) also contends that “unlike in a traditional classroom setting, students need not fear going unheard because they require additional time to formulate their ideas, or because they are timid speakers when in a face-to-face environment” (p. 47). In this sense, active participation of a learner is considered as not just simply posting statements, but as an active involvement in socio-cognitive act of knowledge construction as they critically analyze, evaluate, and formulate the information.

In addition, many researchers claim that computer conferencing possess a potential to facilitate active engagement (Garrison, 1997; Harasim, 1987; Wiesenberg & Hutton, 1996), since it encourages equal participation and eliminates biases or potential stereotyping associated with social cues (e.g., race, gender, and occupation). The advantage of this decreased attention to social status or physical appearance encourages learners to think for themselves and stand by their thoughts (Hillman, 1996), communicate more openly with less inhibition, and confront easily other’s opinions (Sproull & Kiesler, 1991).

Furthermore, through many-to-many communication, a learner may feel obliged to respond to others’ questions or comments that are explicitly linked to his or her statement.

That is, participation in online discussions demands active ongoing verbalization from each member of the learning community. Thus, the process of writing, reading, reflecting, and responding facilitates learners to become more active and constructive in their own learning. In sum, computer conferencing amplifies the activity level of the learner by placing him “in a situation that is likely to exercise the tension between old and new ideas, likely to require adaptation to new ways of conceptualizing, of communicating with people and with ideas; likely to require active involvement in problem-solving, creativity decision-making, and attitude change” (Shedletsky, 1993, p. 8).

Computer conferencing systems (CCS) also support *the second educational principle*: *peer-to-peer interaction is an important source of cognitive development*. As explained in the first part of this chapter, peer-to-peer interaction, or equilibrated exchanges or autonomous relationships by Piagetian terms, has an effective and superior role in cognitive development than coercive, constraint, or heteronomous adult-child relationships. Neo-Piagetian studies indicate that discussions among peers via CCS guide and challenge learners to new levels of growth and understanding (Clements & Nastasi, 1988). According to Tinzmann et al. (1990), it is primarily through discussion and reciprocal interactions (mutual valuing or respecting to different perspectives) that learners construct knowledge.

The attributes of CCS create a shared space, a mutually supportive collaborative environment in which peer-to-peer interaction is encouraged with the opportunity to reflect on alternative perspectives, propositions, and insights. Computer conferencing allows learners to compare, discuss, modify, and identify new perspectives (Harasim, 1990) by communicating with each other across time and space faster than any other medium, allowing at the same time active interaction among those communicating (Mason & Kaye, 1990).

Nyikos and Hashimoto (1997) further advocate that during peer interactions via computer conferencing where learners are exposed to a variety of perspectives, critical thinking and knowledge construction are often promoted. In addition, knowledge construction is facilitated through critical feedbacks, guidance, and help by peers as a result of negotiation and argument of multiple meanings and perspectives. In her study, Burge (1994) noted that "subjects reported the strengths of peer interaction came from the giving of help or from thorough and critical feedback" (p. 35).

Since computer conferencing is mainly based upon written communication as well as time-independent communication, peer interactions or exchanges can become more reflective, critical, and constructive. Many studies support the idea that interaction through text-based communication results in reflective abstraction. Piaget (1995) pointed out that reflective abstraction is the driving force of conceptual change and cognitive restructuring, thereby learning. Fosnot (1996) approached reflective abstraction by emphasizing that "[a]s meaning-makers, humans seek to organize and generalize across experiences in a representational form. Allowing reflection time through journal writing, representation in … discussion of connections across experiences or strategies may facilitate reflective abstraction" (p. 29).

Computer conferencing environments support learners to develop reflective abstraction skills. With the help of CCS attributes, the learner typically follows a reflective process as follows:

1) Reads posted messages and supporting materials

2) Reflects and formulate a response
3) Possibly explores supporting resources (e.g., online experts)
4) Crafts a structured response
5) Edits, assesses, and possibly revises a response upon reflection
6) Presents written response (maybe adding visuals and supporting links)
7) Receives the same type of consideration and feedback from peers, (Prestera & Moller, 2001, p. 7).

A variety of research also shows that computer conferencing supports collaborative and critical dialogues between peers that encourage reflective learning activities (Garrison, 1992; Newman et al., 1997). Therefore, CCS can provide an excellent medium for reflective abstractions as well as logico-mathematical operations through equilibrated exchanges. To give an example, students in a study conducted by Burge (1994) reported they engaged in more reflective activity in computer conferencing than in traditional f2f courses and they were more successful in their learning, due to the opportunity to reflect on content and alternative perspectives.

From this viewpoint, when learners in computer conferencing are confronted by alternative perspectives and opinions, cognitive contradiction or disequilibrium is triggered, thereby nudging learners to search for additional information to resolve that conflict (Piaget, 1985). Thus, *the third educational principle*, cognitive conflict and equilibration, contains critical components in knowledge construction and is also supported by computer conferencing systems. For instance, “active text-based interaction generates a database or web of ideas or responses. The exposure to responses—both positive and negative—

stimulates cognitive restructuring, in response to new information, and to disagreements or challenges encountered in the group discussions" (Harasim, 1990, p. 54).

Through the course of discussing and debating, contradictory viewpoints lead learners to re-conceptualize their thinking by assessing the merits of each varying perspective. Moreover, the presentation of alternative perspectives in computer conference discussions results in perturbations in learners' existing cognitive schema (or present understanding). This challenges encourage them to think more deeply on issues, critically analyze, validate, and actively integrate them into their cognitive framework to construct new knowledge and gain a more meaningful and long-term understanding.

Some educators utilize computer conferencing as a major instructional strategy to create situations that produce disequilibrium for learners. According to Wood, Cobb, and Yackel (1995), the situations students find problematic take a variety of forms:

> (a) resolving obstacles or contradictions that arise when they attempt to make sense of a situation in terms of their current concepts and procedures, (b) accounting for a surprising outcome, (c) verbalizing their mathematical thinking, (d) explaining or justifying a solution, (e) resolving conflicting points of view, or (f) developing a framework that accommodates alternative solution methods and formulating an explanation to clarify another child's solution attempt (p. 413).

In this regard, computer conferencing systems provide situations in which cognitive conflict or disequilibrium is fostered through challenging dialogues that allow learners to "explore and generate many possibilities, both affirming and contradictory" (Fosnot, 1996, p. 29).

In conclusion, computer conferencing can be a useful educational tool in the promotion of active learning and autonomous interactions, and in the modification of existing cognitive systems through the equilibration process involving perturbation-regulation-compensation sequences.

Educators are increasingly adapting the features of computer conferencing in terms of its potential for not only increasing the learner's access to information—and do so powerfully and successfully—but also facilitating knowledge construction activities. For instance, Lauzon (1992) claimed that higher-order learning (e.g., analysis, synthesis, and evaluation) is best achieved in online education through computer conferencing systems. Kaye (1992) also pointed toward the "tools provided by the conferencing system for retrieving and organizing messages, [as] providing perhaps a greater potential for reflective and thoughtful analysis and review of earlier contributions, and hence for mutual elaboration and development, than would, say, participation in a face-to-face seminar" (p. 17). Further, Feenberg (1989) interestingly state that: "a group which exists through an exchange of written texts [i.e., text-based communication] has the peculiar ability to recall and inspect its entire past. Nothing quite like this is available to a community, based on the spoken word" (p. 25).

The Use of Computer Conferencing in Higher Education Environments

Computer-mediated conferencing is becoming increasingly a common instructional strategy in higher education because of its potential to support interaction, collaborative learning, reflective and critical thinking, and knowledge building. It has gained a specific popularity, especially among constructivists, due to its promotion of three main pedagogical implications of constructivist paradigm inspired by Piaget's theory (as explained above).

However, despite its popularity, “the utilization of the medium [i.e., computer conferencing] in education has in many respects outstripped the development of theory on which to base such utilization” (Gunawardena, Lowe, & Anderson, 1997, pp. 397-398). There are few theories and a limited amount of empirical evidence for the claims made about the potential benefits of computer conferencing systems (Garrison et al., 2001; Gunawardena et al., 1997; Henri, 1992; Mason, 1992).

Except for a few recent studies that have focused on the analysis of computer conference transcripts in terms of the quality of learning as well as its educational value (Mason, 1992; Pena-Schaff, Martin, & Gay, 2001), most literature and research findings on the use of computer conferencing in education have generally focused on the potential of this technology to promote and facilitate participation and interaction. Computer-generated statistical manipulations have been a common evaluation tool to examine participation and interaction. The effectiveness of participation and interaction has been defined in narrow quantitative terms such as the number and time of logons, frequency of contributions, length of messages, and number of replies and message chains. These have not yielded information on the quality of learning that takes place in computer conferencing environments (Gunawardena et al., 1997). As Mason (1991) points out: vain

> Very few researchers tackle the difficulties of analyzing the educational quality of conference interactions. … The taint of subjectivity is so threatening, that most computer conferencing research stops with quantitative analyses of messages. … Conclusions as to the revolutionary potential of computer conferencing are, therefore, often drawn with scarcely a mention of the actual content, much less the value, of the interactions (p. 161).

Henri (1992) points out that it is crucial for educators to "posses a body of knowledge regarding the pedagogical characteristics of computer conferences, the scenarios of how the learning occurs, or the elements which give rise to learning." (p. 120). He further emphasizes that "an in-depth study of the meaning of messages will teach us much of interest and importance about the richness of their content, and allow us to pinpoint the information which tells us about learners and learning process" (p.118).

In the next section, the literature on the use of computer conferencing in higher education has been organized to review first, the research related to participation and interaction in computer conferencing; and second, research based on the content of conference transcripts for the educational value of this medium and knowledge or meaning construction.

Participation and Interaction in Computer Conferencing Environments

Ellis and McCreary (1985) conducted a comparative study of two conferences embedded in two courses at the University of Guelph (one is undergraduate and the other is graduate; both courses include a moderator and 4 tutors). They utilized a mixed research method to seek group communications in these two computer conferences. Quantitative analysis was used to determine the rates of moderator and participants' contributions, amount of interaction, types of message content, and pattern of message linkages. Qualitative analysis was conducted to determine the atmosphere and cognitive structure of each conference, based on personal remarks and message clusters linked by the subject.

The results revealed that in the graduate students' conference, there was high participation and interaction, and more clusters of linked comments than those in the undergraduate students' conference. In addition, the rate of the moderator's participation was found higher in the undergraduate conference than in graduate conference. The researchers concluded that the participation of the moderator in conferences has an influential role on the rate of students' participation and interaction—the more the moderator participated, the less the students participated and interacted.

Another study conducted by Hiltz (1986) included three computer conferencing courses offered by the New Jersey Institute of Technology: Computers and Society, The Use of Microcomputers in Teaching, and Personnel Management Techniques as an adjunct mode, in addition to regular class meetings. Hiltz (1986) investigated student perceptions in a computer conferencing environment, whether this environment provided a better learning experience than regular class instruction, and the effectiveness of this environment in supporting more participation and interaction among students. The data were obtained from survey and conference transcripts. Correlations were also conducted between student perceptions of interaction and their assessments of the total value of the computer conferencing experience. The results of this study showed there was a strong correlation between measures of perceived greater interaction with other participants and the perception of having learned more ($r = .59$), and measures of feeling more involved and the perception of having learned more ($r = .51$).

In addition, the findings showed that the nature of the participation differs from a f2f classroom, where there is more interaction among students and less instructor-student interaction, if the design and structure of computer conferencing activities work well. Hiltz (1986) commented on this issue—when the overall course and instructional strategies are well designed, the participation and interaction among students increase in a computer conferencing environment.

Harasim (1987) builds on Hiltz's (1986) work in a study of the use of computer conferencing for cooperative learning in two graduate courses at the Ontario Institute for Studies in Education (OISE). The two courses she studied had the same topic and used two instructional strategies: discussion groups and working groups' activities. The purpose of Harasim's (1987) study was to evaluate computer conferencing within these two instructional strategies as a support for effective and active learning. Data were collected from conference transcripts and the conferencing system generated statistics (i.e., usage data) to determine the rate of participation, size of messages, the degree of intermessage reference (interaction patterns), distribution of communication, and the level of learner-learner interaction (Harasim, 1987).

Harasim (1987) found that students actively participated in course activities, averaging 4.2 hours online per week in once course and 3.6 hours per week in the other course, where the minimum course participation requirement was 2-3 hours per week. In addition, the interaction in both courses took place mainly among students; the contribution of the instructor was found to be relatively equal about 11% of the messages in both courses. The high level of group interaction (65-70%), indicated by learner-learner interaction, was found within conference postings as explicit references to previous messages (e.g., agreeing, debating, questioning, synthesizing or extrapolating). Like Hiltz (1986), Harasim (1987) emphasized the importance and effect of instructional design on participation and interaction among students. She concluded, "[c]omputer-mediated communication can, with sound educational design, provide a highly active and interactive and effective group learning environment" (p. 185).

A case study of the first large-scale use of computer conferencing at the Open University, England was conducted by Mason (1989) to analyze "its effectiveness as a mass teaching medium, its value as a medium for tutoring, and its use as a minor component of a multi-media course" (p. 2). After reviewing the emerging body of computer conferencing literature and drawing comparisons between her results and those of previous studies, Mason (1989), became interested in finding out the reasons for use and nonuse of computer conferencing. To determine these reasons, Mason (1989) utilized student interviews, students' projects, open-ended sections of questionnaires, and participant observation notes regarding students' logons. The analysis of these data showed that the main reasons for nonuse include lack of time, cost of access, the role of conferencing, and the limitations of the medium; the main reasons for use were found to be convenience, increased access to help, and social needs. In addition, 57% of the students reported they were able to participate more equally in conferencing than in f2f communication.

Building on this study, Mason (1991) conducted an in-depth analysis of computer conferencing used as a tutorial support in the course, *Introduction to Information Technology: Social and technological Issues*, with 300 students and 16 tutors. Mason (1991) analyzed computer conferencing messages (the discussion generated 143 messages) to determine their degree of interactivity by using the "islands, dialogues, and webs" typology suggested by Fafchamps et al. (1989). In this structure, islands are defined as messages that do not receive a reply, dialogues refer to sets of two or more messages in which students take turns, and a web develops when there is interactive messaging in terms of receiving and responding to many messages.

Mason (1991) found that most of the contributions to the discussion could be defined as webs, “various themes explored from different perspectives and frequent interweaving of themes explicitly” (p. 18). Twenty-one messages were described as dialogues and only five as islands. Based on Henri’s (1989) framework of evaluating interaction in computer conferencing, she also found that 15% of the postings were independent, while 85% were interactive.

Levin et al. (1990) developed a number of techniques for analyzing instructional interactions on electronic message networks. One of their sequential techniques, the “Intermessage Reference Analysis” was developed to trace multiple threads within computer conferencing. Levin et al. (1990) describe this technique as a more “syntactically” based analysis, “performing the analogue of a repeated reference analysis text. For each message, a coder determines whether reference is made to previous messages” (p. 192). Levin et al. (1990) also used each reference of one message as a link in a graphical representation of messages, what they called “message map.” The second technique they developed was “message act analysis.” They used this technique as an alternative semantic analysis to analyze individual utterances and identify the functions (e.g., instructional functions such as “IRE sequences”) that each message should accomplish. Another technique, the “message flow analysis” was developed to plot the density of messages per unit time, and follow that across time. The message flow analysis on individual postings can be carried out by using the intermessage reference analysis to identify clusters of postings (Levin et al., 1990).

Levin et al. (1990) applied these analytical techniques through the interactions that occurred at the Intercultural Learning Network (ICLN) computer conference. Participants included elementary, middle, and high school students and faculty, and a few participants from outside the educational system from both the United States and other countries. Levin et al. (1990) found 76 intermessage references out of 104 messages by selecting messages sent during April 1986. However, they found that a few messages were referenced multiple times (3 to 5 times), while 54% of the messages were never referenced. As a result of message act analysis, they also found that the conventional IRE sequence (initiation usually by teacher-response, usually by student-evaluation, usually by teacher) was largely missing. Instead, much more complex patterns of interaction were found, where 39% of the initiations and 71% of the evaluations were made by adults. Moreover, as a result of message flow analysis, Levin et al. (1990) found the general level of activity of interactions in computer conferencing similar to that of face-to-face instructions.

Analyzing the Content of Computer Conferencing

Prior to 1992, researchers usually restricted their studies to the gathering of quantitative data on participation and interaction. In these studies, the efficiency and success of interaction was mainly measured by the volume of messages (i.e., the number of messages, the number of server accesses, the duration of contributions, and the number of lines of text transmitted). Therefore, the indicator of the educational value of computer conferencing in learning environments was based on the quantitative dimension of student participation and interaction obtained from automated statistical analysis of computer-generated data. In this regard, Mason (1992) argued that although these analysis techniques with quantitative data provide a useful framework for further research and evaluation, such as the sequential analysis techniques for interaction patterns by Levin et al. (1990), the danger of this type of techniques is that student activity is mistakenly accepted as student learning and group interaction is mistakenly perceived as group communication.

Few studies, however, focused on the analysis of the content of computer conferencing as the key methodology for determining the educational value of this medium and quality of learning by establishing simple categories for a basic analysis of the content of computer conferencing applications (Mason, 1992; Pena-Schaff, Martin, & Gay, 2001). For instance, Vallee et al. (1974) attempted to categorize conference messages into three basic types—problem-solving messages, information exchange, and general discussion; Haile (1986) used four categories—organizational issues, technical help, social, and content-specific; and Kaye (1989) used the same last three categories by Haile (1986)—technical help, social, and content-specific. Vallee et al. (1974) found that "information exchange" comments, usually involve learning about the system, dominated the conference at early portions of discussions. As the conference progressed, more "problem-solving," which was the purpose at hand, took place in participants' entries. Haile (1986) and Kaye (1989) also found that content-specific messages predominated the online discussions among participants.

Mason (1992), reviewing educational methodologies for computer conferencing applications, found no methodologies from within the Postpositivist or Interpretative paradigms, which emerged for undertaking this important educational area—computer conferencing applications. For this reason, Mason (1991, 1992) pursued a different line on content analysis and attempted to draw up a typology of conference messages in relation to their educational value. From this typology, she identified six types of student contributions: 1) personal experiences related to course content; 2) course-related references not included in the course package; 3) comments on both tutors and other students' opinions;4) introduction of new issues for discussion; 5) summaries of previous messages and students' posing questions for the group; and 6) tutor facilitation of discussions.

Mason (1991) also identified three different phases for online discussions as follows: "An initial exploratory phase in which many new ideas and points of view were introduced; a second phase in which students brought in their own experiences and began to build on previous messages; and a final maturing phase in which ideas flowed and links were made between the disparate themes" (p. 168). Mason (1992) noted this method (analyzing the content of online messages) requires a thorough reading of a set of messages with the following six questions in mind to discover the skills and abilities, if any, the participants display and develop: 1) Do the participants build on previous messages? 2) Do they draw on their own experience? 3) Do they refer to course material? 4) Do they refer to relevant material outside the course? 5) Do they initiate new ideas for discussion? And, 6) Does the course tutor control, direct, or facilitate?

Mason's typology could be described as one of the first content analysis approaches to evaluate computer conferencing transcripts. However, the focus of this approach was mainly on the interaction process and the type of content discussed through those interactions rather than the quality of learning process and its outcomes.

According to Henri (1992), who was in search of a specific methodology to analyze computer conference messages, a new content analysis framework needed to be developed. Henri (1992) pointed out the previous studies conducted to evaluate the use of CCS did not yield the tools for the in-depth analysis of message content, so crucial to the learning process. Those studies were deficient, with no aim to understanding the learning process, and interpreting the elements of meaning within the abundance of the data and information contained in the messages (Henri, 1992).

Like McCreary, Henri (1992) believed that the value of computer conferencing applications “lies in its use of the written word – the form of communication which, more than any other, demands exactness, coherent organization of thought, and clear restrained and authentic expression” (p. 199). To possess a body of knowledge about the value and richness of CCS, that is, a better understanding of the scenarios of how the learning takes place or the elements which result in learning, new tools should be provided. As Henri (1992) stated:

> Educators must be provided with the tools to draw the marrow from the bones— to find in the exchanged messages those elements which best reveal the learning process. And a means must also be found of ensuring that new understanding afforded by this analysis is in fact used by educators to support the individual and group learning process (p. 119).

Henri (1992) believed that only an appropriate and “finer grained content analysis” method can help understand and identify this learning process. Therefore, Henri (1992) proposed an analytical method of content analysis containing three main levels of content: 1) what is said on the subject (i.e., exactitude, logic, coherence, relevance, and clarity), 2) how it is said (i.e., the nature of participation, the social presence, and the interactivity factor), and 3) processes and strategies adopted by the learners (i.e., cognitive and metacognitive strategies). The first level deals essentially with the product of learning, and the latter two levels address more of the process of learning.

Based upon these levels, Henri (1992) developed a theoretical framework, which breaks messages into units of meaning and classifies these units based on their content, and has five dimensions in which computer conferencing transcripts can be evaluated: (1) the participative dimension, (2) the social dimension, (3) the interactive dimension, (4) the cognitive dimension, and (5) the metacognitive dimension. Each dimension has operational definitions and identified indicators to allow recognizing the expressions found in the text.

The participative dimension includes the compilation of the number of messages or statements posted by one student or group. This dimension is useful for providing an accurate picture of student participation and can be analyzed in conjunction with data obtained from the other four dimensions.

The social dimension includes the content that reflects the social dynamics of conferencing exchanges, such as self-introduction, salutation, or verbal support. The social statements are not related to the task-related content. Henri (1992) stated this dimension, when analyzed especially with the cognitive dimension, might indicate "the level of learner focus on the task, or the level of social cohesiveness established in the group, or that affective support plays a greater or lesser role in the learning process" (p. 127).

The interactive dimension includes content relating to the interactive contributions to the conference. Henri (1992) categorized these into three interactions: 1) explicit interaction, any statement referring or responding explicitly to another message(s), 2) implicit interaction, any statement taking up and pursuing an expressed idea, referring or responding to another message(s) without direct reference, and 3) independent interaction, any statement of subject under discussion which is neither an answer nor a commentary and has no connection to any other statement. An analysis of interactivity provides information about the structure of conference content, based on either interactive contributions (explicit or implicit interaction) or an accumulation of monologues (independent interaction). The analysis of interactivity would allow us to determine if the learners value other's thoughts, if learning happens only in situations where instructor presence is required, or if the learners have skills to understand, comment, criticize, and incorporate ideas based on previous messages (Henri, 1992).

The cognitive dimension consists of statements within messages indicating the ways people learn or the application of cognitive skills needed to learn how to learn, such as understanding, reasoning, the development of critical skills, and problem resolution (Henri, 1992). To identify skills related to critical reasoning and then to evaluate the level of information processing employed by learners in each of the skills, Henri (1992) defined the following categories to analyze cognitive dimension—elementary clarification, in-depth clarification, inference, judgment, and strategies. Table 3 presents the operational definitions and indicators of these categories and Table 4 illustrates an analytical model of processing information.

Table 3. Analytical Model: Cognitive Skills (Henri, 1992, p. 129)

Reasoning Skills	**Definitions**	**Indicators**
Elementary clarification	Observing or studying a problem identifying its elements, and observing their linkages in order to come to a basic understanding	Identifying relevant elements Reformulating the problem Asking a relevant question Identifying previously stated hypothesis
In-depth clarification	Analyzing and understanding a problem to come to an understanding which sheds light on the values, beliefs, and assumptions which underlie the statement of the problem	Defining the terms Identifying assumptions Establishing referential criteria Seeking out specialized information

Table 3. (continued)

Reasoning Skills	Definitions	Indicators
Inference	Induction and deduction, admitting or proposing an idea on the basis of its link with propositions already admitted as true	Drawing conclusions Making generalizations Formulating a proposition which proceeds from previous statements
Judgment	Making decisions, statements, appreciations, evaluations and criticisms Sizing up	Judging the relevance of solutions Making value judgments Judging inferences
Strategies	Proposing co-ordinated actions for the application of a solution, or for following through on a choice or a decision	Deciding on the action to be taken Proposing one or more solutions Interacting with those concerned

Table 4. Analytical Model: Processing Information (Henri, 1992, p. 130)

Surface Processing	In-Depth Processing
Repeating information contained in the statement of the problem, text, or previous discussion without making any inferences or offering interpretations	Linking facts, ideas, and notions in order to interpret, infer, propose, and judge
Repeating what has been said without adding any new elements	Offering new elements of information
Stating that one shares the ideas or opinions stated, without taking these further or adding any personal comments	Generating new data from information collected by the use of hypotheses and inferences
Proposing solutions without offering explanations	Setting out the advantages and disadvantages of a situation or solution, pros and cons, etc.
Proposing solutions without a sense of implementation criteria and potential problems	Proposing one or more solutions with short-, medium-, and long-term justification

Table 4. (continued)

Surface Processing	In-Depth Processing
Making judgments without offering justification	Making judgments supported by justification
Asking questions which invite information not relevant to the problem or not adding to the understanding of it	Asking questions designed to provoke content-related responses or investigations and further discussion
Offering several solutions without suggesting which is the most appropriate	Providing proof, supporting examples, counterexamples, relevant analogies or metaphors
Providing the situation in a fragmentary or short-term manner	Perceiving the problem within a larger, connected, or more long-term perspective
Failing to suggest how an idea fits within a larger scheme or framework	Developing strategies and ideas within a wider framework or integrative model

Finally, the metacognitive dimension is used to identify mental processes and cognitive mistakes or weaknesses by the learner. Henri (1992) claimed that although the messages cannot be expected to reveal the totality of mental activities, in a computer conferencing environment, however, the examination of transmitted messages can be a valuable source of information on metacognitive dimension. In elaboration of her metacognitive dimension, Henri (1992) made a theoretical distinction between metacognitive knowledge (declarative knowledge pertaining to the person, the task, and the strategies) and metacognitive skills (procedural knowledge in relation to evaluation, planning, regulation and self-awareness). Similar to the cognitive dimension, Henri (1992) provided several operational definitions and indicators for the analysis of this dimension.

Henri's conceptual framework is the first most sophisticated analysis model for the content of CCS. It has been adapted as a major theoretical framework or a premising starting point in many research studies to analyze the content of electronic discussions. For instance, Gunawardena et al. (1997) selected two dimensions— cognitive and metacognitive—of Henri's (1992) model for analyzing the quality of learning experience in an online debate. However, considering the nature and purpose of their study, they found several shortcomings with Henri's framework.

The first shortcoming found in the model was its attempt to recreate the familiar patterns of traditional teaching in computer conferencing environments. According to Gunawardena et al. (1997), Henri's model, based on teacher-centered instructional paradigm, is inappropriate for constructivist learning environments. The next problem with Henri's model was that it is very difficult to distinguish between cognitive and metacognitive dimensions as explained in the model. A large number of statements could be coded as both cognitive and metacognitive. The third objection by Gunawardena et al. (1997) to Henri's model was its treatment of the concept of interaction. Gunawardena and her colleagues found it was mechanistic and descriptive, and not central to the construction of knowledge for a constructivist learning environment.

In addition to these shortcomings found by Gunawardena et al. (1997), Henri's (1992) model was also criticized for not providing an adequate description of the socio-cognitive behaviors learners engage in as they construct knowledge and understanding for themselves. Moreover, Henri's model is lacking in providing evidence about the effectiveness of its dimensions or the details about coding and inter-coder reliability procedures. However, Henri's holistic framework was accepted as a fundamental model and applied by many researchers in their field and the five categories Henri (1992) developed provided a valuable source for those who analyzed the content of computer conferences.

Hara, Bonk, and Angeli (1998) adapted Henri's framework to explore how electronic discussions encourage higher-order cognitive processing as one aspect of their study. For a research setting, they chose an applied cognitive psychology graduate-level residential course, which took advantage of computer conferencing software system (i.e., FirstClass) as a mixed mode of CMC and traditional classroom. This course utilized an instructional method called starter-wrapper technique, where students were responsible for initiating the online discussions and synthesizing it at the end. Four randomly chosen weeks were analyzed, based on Henri's (1992) framework.

The results revealed that *inferencing skills* appeared more frequently in the beginning of the discussion than at the end. Conversely, *cognitive skills* concerning judgment occurred more frequently at the end of the discussion. In addition, of the four weeks of analysis, 33 % of the student postings were at the surface level of information processing; whereas, 55% were at an in-depth level of processing. However, in-depth processing of information jumped to 58% and surface processing reduced to 30% when the starter-wrapper instructional technique was excluded.

Hara et al. (1998) reported that student electronic comments became more interactive over time; however, they are highly dependent on the directions of the discussion starter. Analysis of the study also revealed that students not only shared and compared the information and resources, but also, in fact, processed course information at a fairly high cognitive level. Hara et al. (1998) stated that computer conferencing about course readings results in extremely focused and deep discussions outside of normal class time.

However, as for the key methodological limitations and constraints in this study, they found the cognitive and metacognitive components of Henri's (1992) model as difficult to evaluate and interpret. "While identifying the depth or surface level of processing provides additional information, it is unclear what labels to provide to mixed postings" (Hara et al., 1998, p. 26). According to Hara et al. (1998), another limitation in this study in terms of the total learning experience was the need to look for correlation between student course performance and quality or depth of postings.

Another approach to analyzing computer conference transcripts was developed by Newman, Webb and Cochrane (1995). Newman et al. (1995) developed a content analysis method for measuring critical thinking during group learning via face-to-face and computer conference seminars. Their model was based on a cognitive dimension of Henri's (1992) method of content analysis (described earlier) and Garrison's (1992) model of critical thinking as a 5-stage process, depicted below in Table 5.

Table 5. Garrison's (1992) Five-Stage Critical Thinking Model

Stage 1. Problem Identification [Skill 1. Elementary Clarification]	triggering event arouses and sustains interest and curiosity in a problem—e.g., observing or studying a problem, identifying its elements, and observing their linkages
Stage 2. Problem Definition [Skill 2. In-depth Clarification]	define and frame the problem to its solution—e.g., analyzing a problem to come to an understanding about underlying values, beliefs, and assumptions
Stage 3. Problem Exploration [Skill 3. Inference]	ability to see the problem beyond basis definitions based on deep understanding of situation—e.g., inducting and deducting an idea
Stage 4. Problem Evaluation/Applicability [Skill 4. Judgment]	evaluation of alternative solutions and new ideas—e.g., making decisions, statements, evaluations and criticisms or sizing up
Stage 5. Problem Integration [Skill 5. Strategy Information]	acting upon existing knowledge to validate it—e.g., proposing coordinated actions for the application of a solution or on a choice or decision

Drawing upon the definitions and indicators of Henri (1992) and Garrison (1992), Newman et al. (1995) developed a set of paired indicators to measure the frequencies of specific critical and uncritical skills demonstrated in discussions. Table 6 lists these paired indicators. A phrase, sentence, paragraph or message was selected as a unit of meaning, when it illustrated at least one of the indicators. In addition, a statement that could not be assigned to a particular indicator was simply ignored to ease the task of the evaluators. Each indicator was given a positive or negative value, depending on its presence in the transcripts of tape-recorded seminars and computer conferences. Then, the frequencies for each indicator were tallied and computed ratio, $x \text{ ratio} = (x+ - x-)/(x+ + x-)$, by converting the counts to a -1 (all uncritical, all surface) to +1 (all critical, all deep).

Table 6. Indicators of Critical (+) and Uncritical (-) Thinking (Newman et al., 1995)

	Positive Indicators	**Negative Indicators**
R+- Relevance	R+ relevant statements	R- irrelevant statements, diversions
I+- Importance	I+- important points/issues	I- unimportant, trivial points/issues
N+- Novelty, New Info, Ideas, Solutions	NP+ new problem-related information NI+ new ideas for discussion NS+ new solutions to problems NQ+ welcoming new ideas NL+ learner brings new things in	NP- repeating what has been said NI- false or trivial leads NS- accepting first offered solution NQ- squashing, putting down ideas NL- dragged in by tutor
O+- Bringing Outside Knowledge/ Experience to Bear on Problem	OE+ drawing on personal experience OC+ refer to course material OM+ use relevant outside material OK+ evidence of using previous knowledge OP+ course related problems brought in (e.g., students identify problems from lectures and texts) OQ+ welcoming outside knowledge	O- Sticking to prejudice or assumptions OQ- squashing attempts to bring in outside knowledge

Table 6. (continued)

	Positive Indicators	Negative Indicators
A+- Ambiguities: Clarified or Confused	AC+ clear, unambiguous statements A+ discuss ambiguities to clear them up	AC- confused statements A- continue to ignore ambiguities
L+- Linking Ideas, Interpretation	L+ linking facts, ideas and notions L+ generating new data from information collected	L- repeating information without making inferences or offering an interpretation L- stating that one shares the ideas or opinions stated, without taking these further or adding any personal comments
J+- Justification	JP+ providing proof or examples JS+ justifying solutions or judgments JS+ setting out advantages and disadvantages of situation or solution	JP- irrelevant or obscuring questions or examples JS- offering judgments or solutions without explanations or justifications JS- offering several solutions without suggesting which is the most appropriate
C+- Critical Assessment	C+ critical assessment/evaluation of own or others' contributions CT+ tutor prompts for critical evaluation	C- uncritical acceptance or unreasoned rejection CT- tutor uncritically accepts
P+- Practical Utility (Grounding)	P+ relate possible solutions to familiar situations P+ discuss practical utility of new ideas	P- discuss in a vacuum (treat as if on Mars) P- suggest impractical solutions
W+- Width of Understanding (Complete Picture)	W+ widen discussion (problem within a larger perspective. Intervention strategies within a wider framework)	W- narrow discussion (address bits or fragments of situation. Suggest glib, partial, interventions)

Newman et al. (1995) conducted a controlled experiment in an Information Society undergraduate course. Students participated in half of the course seminars in f2f meetings, and half via computer conferencing. Each week, some of the students discussed issues in f2f meetings, while others discussed over computer conferencing, which continued for two weeks at a time on a computer conferencing system. Each group used both methods to discuss the topics within course lectures. The purpose of course seminars was to encourage students to critically think course-related issues.

The results of this study indicated that students who participated in computer conference seminars had significantly deeper overall critical thinking rates than those who participated in f2f seminars. Newman et al. (1995) found that although more new ideas emerged in the face-to-face seminars, computer conference discussions generated more ideas that were linked together and justified. Even when students said less in the computer conference seminars than in the f2f seminars, students in CMC-based seminars more often brought in outside materials and experiences in their discussions to link facts, ideas, and notions together.

Newman et al.'s (1995) study provides useful indicators and a coding scheme for analyzing critical thinking skills in computer conferencing. On the other hand, Newman et al.'s (1995) recommended an improvement in their model for further studies, especially with the clarification of some of the indicators which reveal a certain amount of ambiguity and overlap.

Zhu (1996) also conducted a content analysis using a constructivist framework approach to evaluate meaning negotiation and knowledge construction in a 16-week graduate distance education course via computer conferencing. Zhu conducted a quantitative analysis of all the data obtained from computer conference discussions plus a more exhaustive qualitative analysis on two randomly selected weeks. For qualitative analysis, the messages were coded into participation categories and participant's roles. Zhu (1996) developed a coding scheme consisting of participant categories (contributor, wanderer, seeker, and mentor), types of interaction based on Hatano and Inagaki's (1991) theory of group interaction (vertical and horizontal), and notes-meaning categories (question, answer, reflection, comments, discussion, information sharing, scaffolding, and answer).

The results of Zhu's (1996) study showed that the participation rate of students increased from 35% during the first week to 95% in week number 11, and the overall student participation was over 73%. In addition, the results of the analysis of two randomly selected weeks indicated that instructors acted like mentors and almost all students participated in electronic discussions. Forty-one percent of the students' contributions were categorized as discussion, 23% as comment, 6.2% as reflection, 5% as information, and 9% as scaffolding. Furthermore, Zhu (1996) found only two information seeking questions in the analysis of the selected weeks and the predominant type of interaction was horizontal.

Pena-Shaff, Martin, and Gay (2001) conducted a case study to analyze communication patterns and knowledge construction processes of students who used two forms of CMC to discuss course-related topics—an asynchronous bulletin board (BBS) and a synchronous text chat environment, Internet Relay Chat (IRC). For the objective of this dissertation, only the BBS results are discussed. The data were collected from the electronic transcripts of the BBS in a 14 week-long elective course at Cornell University, including 6 graduate and 18 undergraduate students.

Pena-Shaff, Martin, and Gay (2001) developed a category system for analyzing the messages posted in the BBS. This category system was developed, based on grounded theory. The category system was developed on the basis of the type of learning process and whether the messages were or were not interactive. Thirteen different categories for the learning process and two different levels of interactivity (i.e., monologue or independent, and explicit or implicit interactivity) were developed. Table 7 shows the category system, or coding scheme with descriptors developed.

Table 7. Coding Scheme (Pena-Shaff, Martin, & Gay, 2001)

CATEGORY	DESCRIPTION
Monologue messages – Not necessarily Interactive	
Reflective Analysis (RA)	Self-questioning: Questions answered by the participant in the same message – questioning him/herself about the topic. Analysis-Reasoning: Decomposition of ideas, searching for causes and consequences, evaluating ideas, self-explanations, and self-arguments. Conclusion building: reaching conclusions based on self-analysis of facts and ideas. Hypothesis building: Developing hypothesis based on the readings, own arguments and other participants' comments. Inferences. Use of analogies: Using previous knowledge, comparison to similar situations in other areas. Surprise: Acknowledgement of finding something new, learning something new.
Subjective Analysis (SA)	Value-based: Messages showing strong personal beliefs. Non-objective analysis. Strong ethical and moral arguments toward the issue being addressed. Emotional responses: Expression of feelings detonated by the reading assignment.
Task Related (TR)	Reading-related: Referring to, paraphrasing, summarizing or using ideas from the readings. Class-related: Referring to or summarizing issues discussed in class or using as example class activities and discussions. Focusing: Bringing online discussion back to focus when deviated.
Both interactive and non-interactive	
Assertion (A)	Maintaining, providing arguments to defend their points of view.
Experiential (E)	Using personal experiences and previous knowledge that relate to the topic being discussed.
Topic Evaluation (TE)	Analyzing text orientation, what is ignored or included in the text, analyzing author's position.
Off Task (OT)	Messages not related to the topic under discussion.

Table 7. (continued)

Interactive Messages – Collaborative Dialogue	
Question (Q)	Posing questions that need some sort of reply from the group: clarification, explanation, examples, etc.
Reply (R)	Answering other participant's question either directly or indirectly. Example: "Responding to XXX question, I think…" or addressing the issue without making reference to the question being responded.
Support (S)	Agreement: Agreeing with other people's ideas either explicitly "I agree with …" or indirectly "I would like to add" or "I also think that…" Empathy: Sharing feeling with other participants' comments. Acknowledgment: Acknowledging other participants' ideas and comments. Feedback: Addressing other people's comments, acknowledging their concerns.
Consensus Building (CB)	Conflict: Disagreements, argumentation, friction, negotiation. Reaching agreement: Building arguments collaboratively, generating group conclusions.
Clarification/ Elaboration (CE)	Brainstorming: Idea-generation, presenting different ideas and arguments. Providing examples, arguments and ideas to answer other participants' questions, or to explain own argument.
Social Interaction (SI)	Greetings, jokes, expression of emotions based on other people's comments (laugh, surprise and discomfort), use of nicknames.

The findings by Pena-Shaff et al.'s (2001) study showed evidence in few messages for statements coded as conflict (6%), brainstorming (4%), social interactions (4%), off-task messages (4%) or attempts to bring discussion back to topic (2%). Messages were most frequently task-related (89%). The researchers found that most of the discussions held in the BBS were of high quality, presenting reflective, coherent, deep, and thoughtful comments. Most of the messages showed evidence for sophisticated reflective practices, such as self-questioning (20.3%), reasoning (19.5%), argumentation (19.5%), conclusion building (12%), and hypothesis building (12%). One interesting result was that although there were interactions in discussions and messages showed reflective analysis, subjective analysis or task-related activities, many of the messages (69%) were monologue, a conversation with the self. According to Pena-Shaff et al. (2001), many of the statements posed by students showed what Vygotsky (1962) described as deliberate analytical action and purposeful construction of meaning.

In general, Pena-Shaff et al. (2001) suggested that a CMC environment can be a useful tool for students by providing them their own forum to initiate discussion, construct arguments, and produce new meanings; and for teachers, who seek to promote critical thinking skills, reflective thought, and in-depth analysis of course-related content including peer contributions. From the analysis of message content, Pena-Shaff et al. (2001) also pointed out that asynchronous discussion environments increase opportunities

> To develop sophisticated cognitive skills such as self-reflection, critical thinking and indepth analysis of the course content, supporting the purposeful construction of meaning. The need to articulate one's own argument in this type of text-based environment encourages students to engage in analytical and reflective action. This process helps students construct purposeful arguments and transmit them to an audience (p. 65).

Finally, Garrison, Anderson, and Archer (2001) developed a conceptual model, "community of inquiry," to examine the use of computer conferencing in supporting an educational experience. This model consists of three complementary and partially overlapping elements—social presence, cognitive presence, and teaching presence. In this model, cognitive presence was considered as a vital element in critical thinking, as an outcome and product, the acquisition of deep and meaningful understanding, and critical inquiry abilities, skills, and dispositions; social presence was defined as the ability of participants to project or present themselves to the other participants in the community of inquiry; and teacher presence included two functions, design of the educational experience and facilitation. According to Garrison et al. (2001), a learning experience occurs within a community through the interaction of those three fundamental elements.

However, cognitive presence is the main element in creating knowledge and critical thinking skills; social presence and teacher presence function as a support for cognitive presence, indirectly facilitating the process of critical thinking (Garrison et al., 2001). According to Garrison et al. (2001), the ability of learners to construct and confirm meaning through sustained reflection and discourse defines the cognitive presence.

Garrison, Anderson, and Archer (2000) developed a practical inquiry model to assess cognitive presence (i.e., critical inquiry) in an online, computer conference environment. The Practical Inquiry Model consists of four phases essential to describe and understand cognitive presence in a learning environment (Garrison et al., 2001): 1) triggering (posing the dilemma or problem to initiate the phase), 2) exploration (exploration of relevant information between critical reflection and discourse), 3) integration (construction of meanings and possible solution generated in the exploratory phase), and 4) resolution (critical assessment of solution by means of direct and vicarious action). Figure 7 illustrates the practical inquiry model with its four phases.

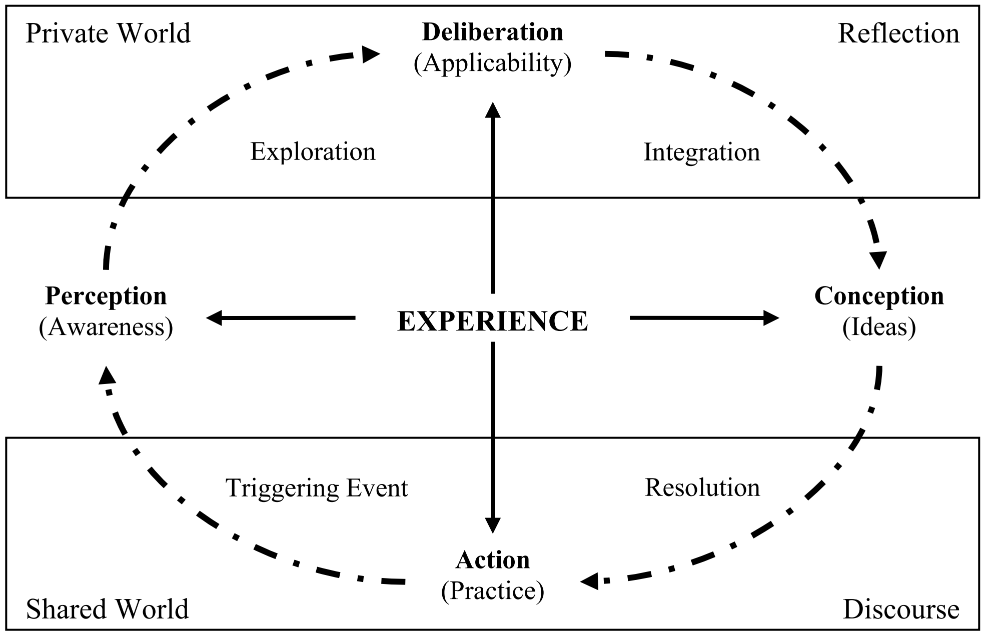


Figure 7. Practical Inquiry Model (Garrison, Anderson, Archer, 2000)

Garrison et al. (2000) noted that "the model presented here assumes an iterative and reciprocal relationship between personal and shared worlds. That is, there is a synergy between reflection and communicative action. Critical thinking is the integration of deliberation and action. This reflects the dynamic relationship between personal meaning and shared understanding" (p. 19). Garrison et al. (2001) developed a coding scheme to analyze cognitive presence in the computer conference transcripts by establishing definitions and indicators for each phase of the Practical Inquiry Model. Table 8 below demonstrates this coding scheme.

Garrison et al. (2001) conducted the Practical Inquiry Model to assess the nature and quality of the critical-thinking processes (i.e., cognitive presence) as reflected in a computer conference transcript. They applied their model in three one-week exchanges from two graduate-level computer conference courses. In the first transcript, the instructor, two moderators and 11 students exchanged a total of 51 messages posted during the conference week; in the second transcript, the instructor and six students exchanged 20 messages; and in the third transcript, the instructor and four students exchanged 24 messages. The principal investigator and two graduate students coded the selected transcripts, using coefficient of reliability (CR) and Cohen's (1960) kappa (k). The inter-rater reliability for three transcripts were CR = .45, .65, and .84 and k = .35, .49, and .74. These values were acknowledged by the researchers to be low, but the argument was made by concurring with Riffe et al.'s (1998) statement, "research that is breaking new ground with concepts that are rich in analytical value may go forward with reliability levels somewhat below that range" (p. 31).

Table 8. Cognitive Presence Coding Scheme (Garrison et al., 2001)

Descriptor	Indicators	Socio-cognitive process
Phase 1- Evocative	TRIGGERING EVENTS	
	Recognizing the problem	Presenting background information that culminates in a question.
	Sense of puzzlement	Asking questions.
		Messages that take discussion in new direction.
Phase 2- Tentative	EXPLORATION	
	Divergence - within the online community	Unsubstantiated contradiction of previous ideas.
	Divergence - within a single message	Many different ideas/themes presented in one message.
	Information exchange	Personal narratives/descriptions/facts (not used as evidence to support a conclusion).
	Suggestions for consideration	Author explicitly characterizes message as exploration, e.g., "Does that seem about right?" "Am I way off the mark?"
	Brainstorming	Adds to established points but does not systematically defend/justify/develop addition.
	Leaps to conclusions	Offers unsupported opinions.

Table 8. (continued)

Phase 3 - Provisional	INTEGRATION	
	Convergence – among group members	Reference to previous message followed by substantiated agreement, e.g., “I agree because…” Building on, adding to others’ ideas.
	Convergence – within a single message	Justified, developed, defensible, yet tentative hypotheses.
	Connecting ideas, synthesis	Integrating information from various sources – textbook, articles, personal experience
	Creating solutions	Explicit characterization of message as a solution by participant
Phase 4 - Committed	RESOLUTION	
	Vicarious application to real world	None
	Testing solutions	Coded
	Defending solutions	

They found that the first phase of the practical inquiry model, trigger, had 8% of the coded responses in the transcripts. The second phase, exploration, had the highest frequency (42%); the frequency of responses in the third phase, integration, was 13%, and the fourth phase, resolution, was 4%. The results showed that the majority of the students’ postings indicated that students brainstormed, shared, and compared their insights and contributed relevant information. Garrison et al. (2001) stated that the transcripts reflected little of the integration phase, due to the fact that it requires time for reflection to synthesize the information and it may be risky for students to offer tentative solutions, where their hypotheses may be rejected.

In addition, the reason little attention was focused on the exploration phase was assumed to be dependent on three factors. The first factor was associated with the instructional design and facilitation; the second factor was assumed to be related to the computer conferencing medium; and the third factor for the lack of resolution could be that the practical inquiry model was not appropriate for this study.

Garrison et al.'s (2001) model was found challenging by the difficulty of measuring latent variables and difficulty of deal with large numbers of messages generated during long-term courses. Moreover, the categories in practical inquiry model are so heavily weighted and inclusive that it is difficult to draw meaningful conclusions. However, their model with descriptors, indicators, and examples provides a useful framework for further research to better understand the cognitive presence of the teaching and learning transactions in computer conferencing environments.

Pawan et al. (2003) adapted the Practical Inquiry Model (Garrison et al., 2001) as a theoretical framework in their study to investigate and understand the collaborative learning as well as a cognitive presence in a computer conferencing environment. This study examined online discussions from three graduate-level language teacher education courses (Literature Instruction, Teaching Critical Reading Skills, and Technology in Language Teaching) at a large midwestern U.S. university. The data collected from the messages posted by 36 students in two weeks of discourse from each class, comprised 160 messages. The discussion weeks were randomly selected. The researchers used 'speech segment' (the smallest unit of delivery linked to a single theme) as their unit of analysis for the coding procedure and inter-rater agreement was 94%.

The findings were similar to those of Garrison et al.'s (2001) study. Pawan et al. (2003) found that the online discussions centered on Phase 2 (Exploration: 66%), with few in Phase 3 (Integration: 11%) and none in Phase 4 (Resolution). According to their findings, students were mostly sharing information and brainstorming their own ideas, including personal narratives, descriptions, issues, problems, and facts posted by the instructor and others, rather than critical and reflective exchanges such as challenging and questioning each other's points of view. Only 11% of the messages revealed that participants did build upon ideas suggested by others and pull together information shared by others to construct and negotiate new meanings. Pawan et al. (2003) remarked that several limitations were found with the practical inquiry model. They stated there was a missing coding category to qualify for movement from Phase 2 (Exploration) to Phase 3 (Integration) of the model. In addition, there was difficulty in using the practical inquiry model to distinguish between very similar indicators in the subcategories, which might cause a lack of inter-rater reliability.

Summary of the Research on the Use of CCS

Early research of the use of computer conferencing focused, in general, on participation and interaction issues in quantitative terms. Although some of these studies have provided different results, participation and interaction was found relatively high in online discussions or at least as high as those in f2f classrooms. Findings that were common to most of these studies were that computer conferencing employed results in participation and interaction among students through discussions that differ from traditional classroom environment. There were more peer interactions and less instructor contributions. That is, the attributes of this technology provided a context in which more participation and interaction among students were encouraged in comparable to face-to-face situations. However, it was also reported that CCS per se would not guarantee increased participation and interaction. Most researchers agreed that improved outcomes of using computer conferencing are dependent on effective instructional design, based upon several variables such as learner characteristics, needs and goals, nonverbal cues, access to the medium, and a careful integration into the curriculum.

On the other hand, while these studies did provide valuable findings in terms of describing and analyzing participation and interaction, most failed to address the issue of whether or not these methods actually evaluated the learning experiences of students rather than their rates of participation. It was not until the last decade that many researchers attempted to analyze the educational quality of exchanges via computer conferencing. Most of these studies attempted to focus on the content of electronic messages to analyze cognitive presence or critical thinking skills (Garrison et al., 2001; Henri, 1992; Newman et al., 1995) and social construction of knowledge (Gunawardena et al., 1997; Pena-Shaff et al., 2001; Zhu, 1996). The most common findings of these studies were that online discussions favor and increase the use of critical thinking skills and enable students to construct new meanings or knowledge through reflection, peer-interaction, and reasoning. Table 9 summarizes the use of computer conferencing systems in education.

Table 9. Summary of Research on the Use of CCS

Study	Variables Investigated	Research Method	Context, Contribution & Findings
Ellis & McCreary (1985)	Participation, interaction	Comparative study Mixed research: quantitative (computer-generated statistics) & qualitative (classification of personal remarks and cognitive structure of each conference)	▪ Undergraduate & graduate students ▪ Higher levels of participation, interaction and synergy, and more clusters of linked comments among graduate students than that among undergraduates ▪ Moderator more active in undergraduate conference. ▪ The more the moderator or instructor participated the less the students participated and interacted
Hiltz (1986)	Participation, interaction Student perceptions on CCS	Descriptive and experimental study Survey and conference transcripts	▪ Undergraduate & graduate students using computer conferencing as an adjunct mode ▪ Strong correlation between measures of perceived greater interaction with other participants and the perception of having learned more (r =.59), and measures of feeling more involved and the perception of having learned more (r =.51) ▪ Good instructional design promotes more participation and interaction among students in CCS
Harasim (1987)	Participation, interaction Type of messages	Descriptive study Computer-generated statistics Conference transcripts Intermessage reference analysis	▪ Graduate students from two distance courses ▪ Active participation and high levels of peer interaction in course activities ▪ High level of intermessage reference: Evidence of explicit messages between learners such as agreeing, debating, questioning, synthesizing or extrapolating ▪ Careful educational design can provide a highly active and interactive and effective group learning environment

Table 9. (continued)

Study	**Variables Investigated**	**Research Method**	**Context, Contribution & Findings**
Mason (1989)	Participation	Student interviews, students' projects, open-ended sections of questionnaires, and participant observation notes regarding students' logons (participation).	▪ Undergraduate, distance education, open university ▪ Unequal levels of participation. ▪ Reasons for use and nonuse of CCS investigated ▪ The main reasons for nonuse: lack of time, cost of access, the role of conferencing, and the limitations of the medium ▪ Communication mainly related to help and social needs
Levin et al. (1990)	Interaction	Descriptive study (Interaction Analysis)	▪ Developed sequential analytical techniques to analyze interaction patterns: "intermessage reference analysis"; "message act analysis"; "message flow analysis" ▪ Intercultural Learning Network (ICLN) computer conference included elementary, middle, and high school students and faculty, and a few participants from outside the educational system from both US and other countries ▪ Low intermessage references ▪ Complex patterns of interaction ▪ Similarity between computer conferencing and f2f in terms of the level of activity of interactions
Mason (1991)	Interaction	Coded transcripts based on their degree of interactivity by using the "islands, dialogues, and webs" typology suggested by Fafchamps et al. (1989)	▪ Undergraduate distance learning course ▪ 85% of the messages categorized as "webs" ▪ Increased student interactivity

Table 9. (continued)

Study	Variables Investigated	Research Method	Context, Contribution & Findings
Mason (1991)	Participation, interaction process and the type of content discussed through those interactions	Descriptive Study (Content Analysis)	▪ Developed a typology to identify six types of contribution as an initial approach to evaluate the content of messages ▪ Interaction among participants revealed reflective, self-directive, and active mode of learning
Henri (1992)	Participation, interaction, social, cognitive, and metacognitive	Descriptive Study (Content Analysis)	▪ Developed a first most sophisticated theoretical framework for the analysis of the content of computer conference messages
Newman et al. (1995)	Critical thinking	Descriptive Study (Content Analysis) Controlled experiment	▪ Developed a content analysis method for measuring critical thinking ▪ Undergraduate course ▪ Evidence of critical thinking with significantly deeper overall critical thinking ratios in computer conferencing than f2f seminars ▪ Found computer conference discussions generated more ideas that were linked together and justified
Zhu (1996)	interaction, participation participant roles knowledge construction	Descriptive study, Quantitative and qualitative analysis	▪ Developed a coding scheme based on participant categories, types of interaction, and notes-meaning categories ▪ Graduate course ▪ the overall student participation over 73% ▪ 41% of students' contributions categorized as discussion, 23% comment, 6.2% reflection, 5% information, and 9% scaffolding

Table 9. (continued)

Study	Variables Investigated	Research Method	Context, Contribution & Findings
Gunawardena et al. (1997)	Knowledge construction	Content analysis, descriptive study	▪ Developed a theoretical framework called "Interaction Analysis Model" ▪ The discussions were fairly high in quality demonstrating all five phases of IAM with the majority of postings occurred at phases II & III ▪ Found the evidences indicating that participants' knowledge or their ways of thinking have changed ▪ Overall the interaction analysis model was able to determine that knowledge construction occurred through computer conferencing
Hara et al. (1998)	higher-order cognitive processing	content analysis based on Henri's (1992) model	▪ Graduate students; computer conferencing used as an adjunct mode. ▪ Inferencing skills appeared more frequently in the beginning ▪ cognitive skills concerning 'judgment' occurred more frequently at the end of the discussions ▪ student electronic comments became more interactive over time ▪ students processed course information at a fairly high cognitive level via extremely focused and deep discussions outside of normal class time ▪ students highly dependent on the directions of discussion starter

Table 9. (continued)

Study	Variables Investigated	Research Method	Context, Contribution & Findings
Pena-Shaff (2001)	Communication patterns Meaning construction processes	Case study	▪ Developed a category system emerged from the data ▪ Graduate and undergraduate students in an elective 14 week-long course ▪ Found students engaged in most frequently task-related activities (89%) ▪ Most of the messages showed the evidence for sophisticated reflective practices such as self-questioning (20.3%), reasoning (19.5%), argumentation (19.5%), conclusion building (12%), and hypothesis building (12%) ▪ Many of the messages (69%) were monologue
Garrison et al. (2000, 2001)	Critical thinking	Content analysis	▪ Developed a conceptual model called "Practical Inquiry Model" ▪ Graduate courses through computer conferencing ▪ The second phase of their model (i.e., exploration) had the highest frequency (42%) ▪ The majority of students' postings indicated that students brainstormed, shared and compared their insights and contributed relevant information
Pawan et al. (2003)	Collaborative learning Cognitive presence	Content analysis Adapted Garrison et al's (2001) practical inquiry model	▪ Graduate courses online discussions centered on Phase 2 (Exploration: 66%): sharing information and brainstorming ideas including personal narratives, descriptions, issues, problems, and facts posed by the instructor and others ▪ Only 11% of the messages revealed that participants did build upon ideas

It is difficult to make generalizations across these studies reviewed, due to the fact they vary considerably in terms of purpose and context. But, it can be said that most studies failed to consider the notions of participation, interaction, and cognitive presence or knowledge construction as a whole in the learning experience. Although some studies tried to include these aspects in their research purpose, the emphasis was mainly one-faceted. In addition, many studies did not analyze or evaluate the quality of learning in the CCS environment, based on an educational principle or theoretical framework. It was not clear how they reached conclusions such as cognitive maturity of learners, self-reflective learning, or knowledge development. There were almost no details about their theoretical foundations applicable to active participation and interaction, meaning creation, knowledge construction, and so on.

The following chapter describes the research design and methodology used to achieve the purposes and focus of this study.

CHAPTER III: RESEARCH DESIGN AND METHODOLOGY

Mixed methods research approach was used in this study to investigate the knowledge construction process through computer conferencing. Mixed methods research is defined as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language in a single study" (Johnson & Onwuegbuzie, 2004, p. 17).

There has been considerable debate in the literature about the dichotomy of quantitative and qualitative research paradigms (Raudenbush, 2004). Some supporters of both paradigms view their research method as the ideal one, and advocate that quantitative and qualitative research paradigms are epistemologically incompatible with each other so they cannot and should not be mixed (Lincoln & Guba, 1989). However, many scholars contend that quantitative and qualitative research methods are complementary, and when appropriately used can increase the quality of the final results and provide a more comprehensive understanding of analyzed phenomena (Borg & Gall, 1996; Bryman, 1998; Firestone, 1987; Patton, 1990).

Mixed methods research has been advocated as a peaceful resolution to paradigm wars, and an alternative logical and practical research paradigm to quantitative and qualitative paradigms (Johnson & Onweugbuzie, 2004). Raudenbush (2004) claims that if mixed methods research was used, then "the resulting inquiry will be more credible, more useful, or more comprehensive than would have been the case if any single methodological approach had been adopted alone" (p. 4).

The mixed methods research approach was chosen for this study because of the nature of research objectives and questions. As discussed in Chapter I, the main focus of this study was on understanding the knowledge construction process of students through online discussions using a computer conferencing tool. Therefore, this study aimed to describe and analyze both the quantitative and qualitative characteristics of knowledge construction in computer conference discussions. A conceptual model (see Figure 8), guided mixed methods research methodology and was developed by the researcher, based on pedagogical implications of Piaget's constructivist theory.

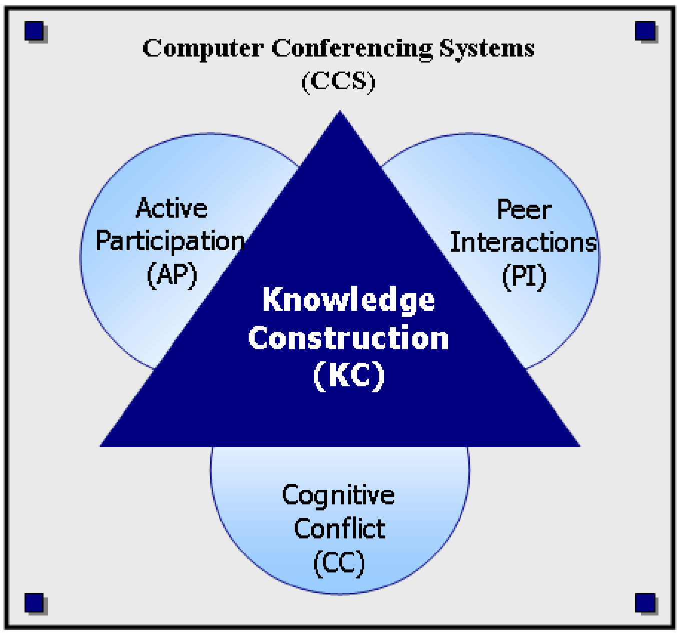


Figure 8. Knowledge Construction Conceptual Research Model

Knowledge construction was investigated from three aspects: (a) Active Participation: students are active participants in constructing their own knowledge, (b) Peer Interactions: students construct better knowledge through peer-peer interactions, or equilibrated exchanges, and (c) Cognitive Conflict: students construct knowledge through cognitive conflict resolution. Research purposes, objectives and questions, and data analysis procedures in this study were designed based on this model.

The quantitative method used in this study focuses on the participation rate and change, interaction patterns and maps, and the frequency of the indicators of the knowledge construction process. The qualitative method focuses on descriptive and detailed analysis of interaction types and the knowledge construction process exhibited in computer conference discussions. These methods are described in detail in the proceeding pages.

The Context

The study was carried out at a large midwestern U.S. university in two online courses about the ethical issues in biotechnology. These two courses, "Ethics and Biotechnology" and "Ethics and Animals," were held at the same time. Each course was two staff development credits (for Iowa residents only) or one graduate credit for other participants. These courses were designed as part of the Bioethics Outreach Program through the Office of Biotechnology for K-12 teachers, extension personnel, 4-H leaders, and others, who educate youth and adult learners about ethical issues (e.g., influential moral theories) surrounding biotechnology in the life sciences. The main objectives of these courses were to enable participants to critically discuss bioethics issues, learn how to incorporate bioethics into their classroom, and teach others about issues surrounding particular biotechnologies.

Specifically, the description and goal of each of the two courses as stated in the course syllabus were:

> *Ethics and Biotechnology*. Modern biotechnology is as controversial as it is promising. Teaching the associated ethical issues can help engage students to learn the relevant science concepts and to learn the skills necessary to contribute to ongoing social dialogue about science and society. Topics include an overview of ethical

controversies about biotechnology and specific ethical issues in plant, animal, and human biotechnology (Appendix A).

Ethics and Animals. This course will enable participants to recognize and distinguish different views about the moral status of animals; to articulate and defend their own ideas about the ethics of using animals for food, research, and education; and to incorporate ethical issues concerning animals in their courses. This course will benefit educators who discuss or use animals in their courses or outreach efforts, as well as social studies teachers interested in current controversies about society's uses of animals (Appendix B).

Enrollment in these courses was voluntary and all class work was completed online. Courses were taught by the same professor, who had considerable experience in bioethics and related fields, including moral and political philosophy, and who had offered the same courses for two years using online communication tools.

Selection Criteria of the Bioethics Courses as Research Context

The general focus of this study was to examine the knowledge construction process in a computer conferencing system. Bioethics courses were selected as a research context, based on criteria that included:

- Professional adult learners who have various experience and knowledge for exchanges through computer conferencing.
- A course that adopts constructivist learning and teaching principles.
- A course that encourages extensive discussions among students.
- A course that encourages participation, critical thinking, and knowledge construction.

Course Requirements

Students were required to complete several assignments in each of the two courses. Assignments common to both courses included participating in class discussions and writing a position paper. Class discussions were critical to the present study. Participation in class discussions was required with at least three considerable messages per week in a computer conferencing system. Students were told in the course syllabus to plan to complete the reading for each section early in the week and to give themselves time to reflect on the material before they participate in the discussion. While discussion forums stayed open after the section was completed, only posts made during the period of the section were counted towards students' discussion grades. Participation in online discussions constituted 60% of the students' final grade. Grades were assigned by the instructor using a rubric (see Table 10).

Table 10. Grading Rubric for Discussions

Category	1	2	3	4
Promptness and Initiative	Does not respond to most postings; rarely participates freely	Responds to most postings several days after initial discussion: limited initiative	Responds to most postings within a 48 hour period; requires occasional prompting to post	Consistently responds to postings in less than 48 hours: demonstrates initiative
Delivery of Post	Utilizes poor spelling and grammar in most posts; post appear "hasty"	Errors in spelling and grammar evidenced in several posts	Few grammatical or spelling errors in posts	Postings are consistently grammatically correct, rare misspelling
Relevance of Post	Postings often do not relate to the discussion content; makes short or irrelevant remarks	Occasionally posts off-topic; most posts are short in length and offer little or no new insight into the topic	Postings are frequently related to discussion content; prompts further discussion of topic	Postings are consistently related to discussion content; cites additional references related to topic

Table 10. (continued)

Category	1	2	3	4
Expression within the Post	Does not express opinions or ideas clearly	Opinions and ideas sometimes expressed clearly	Opinions and ideas are usually stated clearly	Consistently expressed opinions and ideas in a clear and concise manner
Contribution to the Learning Community	Does not make effort to participate in learning community as it develops; seems indifferent	Occasional or marginal effort to become involved with group	Frequently attempts to present relevant viewpoints for consideration with group; interacts freely	Aware of needs of community; frequently attempts to motivate the group discussion; presents creative approaches to topic

Students were also required to write a position paper (40% of the final grade), which gave them experience in designing their own arguments throughout the course. They worked on the same position paper throughout the course by revising their work in response to comments and suggestions from the instructor. A draft was due each week and the instructor provided feedback on the students' understanding of the issue.

This assignment was designed to help students understand the issues they were discussing in the course by using the course material to support a thesis about ethics and biotechnology. Students were graded not on what thesis they picked to defend, but on the following considerations: (1) whether the paper demonstrated an understanding of the material they discussed and read; (2) how well they marshaled the material from the course in support of their view; and (3) how coherent, focused, and lucid their paper was overall.

Course Structure

The structure of each course was similar. Each module was divided into a 3-week session and required a minimum of 15 hours of online participation in total, plus an additional 15 hours of reading, writing, and research. All course materials, such as the course syllabus, readings, case study examples, and other resources, were available online for participants. These two courses were conducted via WebCT, a web-based course management system. Figure 9 illustrates the WebCT course tools designed by the instructor used for each Bioethics course.

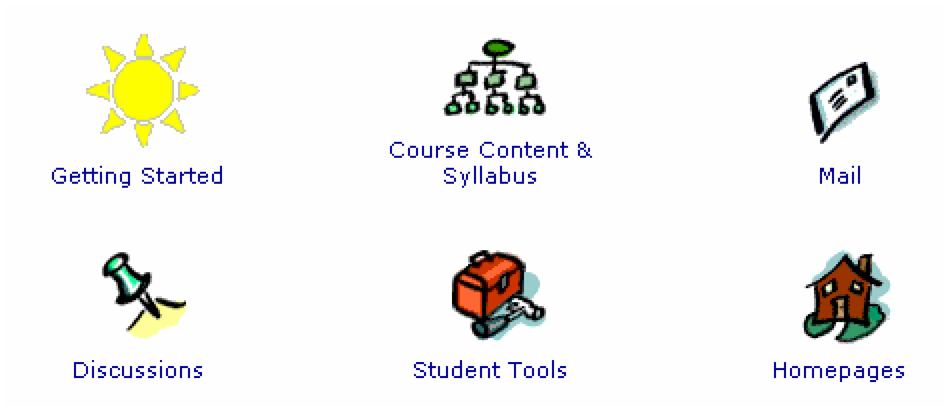


Figure 9. WebCT Course Tools for Each Bioethics Course.

Getting Started was an orientation page, that included information about the course and practices (e.g., sending first email, posting first message, and creating a homepage) for students to become familiar with WebCT environment. The *Course Content & Syllabus* section included course readings, hyperlinks to other course-related resources, and general information about the course's organization, description, and objectives of the assignments and weekly lessons.

For the *course content*, the instructor presented the course content under several topics each week within WebCT content pages. These pages included subject-matter knowledge that had hyperlinks to other online resources. The presentation of the information was not static but interactive. That is, the instructor asked triggering questions, either in the middle or at the end of the online content, to make students interact with the content, encourage them to critically think about, and assess their current knowledge as well as create contradictions with, or curiosity for, new information. In response to questions, students were required to share their opinions and responses to questions by posting statements in the Discussion Board area.

Because the content introduced very abstract ideas about ethical issues, different case study activities were designed for students to evaluate for use in various circumstances and to focus attention on the ethical aspects of the concrete issues. The case study format allowed for more detailed discussion of a particular issue, because it provided a forum for investigating a particular issue in more depth (K. Hesslerr, personal communication, March 14, 2006).

Mail tool allowed course participants to communicate as one-to-one or one-to-many by sending and receiving electronic messages. For instance, some students preferred to submit their position paper via the mail tool, to interact with another course participant, or the instructor in private. *Student Tools* allowed students to see their grades, see others' postings in the Discussion Board, and search easily discussion topics that were in their interests. *Homepages* allowed students to create a personal webpage to get to know each other (i.e., create a social presence) by including demographic information about themselves (e.g., interests, hobbies, occupation, etc.).

Discussions through the computer conferencing tool within the WebCT environment was a vital component of the course structure. It provided the primary environment in which most of the interactions and learning occurred. Students discussed course-related issues during each week using this tool. This tool provided opportunity for students to participate in discussions anytime and anywhere. However, students had to be discussing the same topics at roughly the same time. Discussions were asynchronous, but temporal. Because the exchange of ideas was the main focus of the courses, it was imperative to participate in discussions regularly and work collaboratively to maintain the flow of the discussions.

During discussions, the instructor generally acted as a facilitator and did not participate directly in discussions. This allowed students to more freely interact with each other. Students engaged with the resources provided in the course in an active and critical way, and reacted to issues raised in the resources from their own perspectives in discussions. Discussions were usually open-ended, and students simply shared their first reactions to the course material. Students were free to start a conversation on any topic from their readings and experiences. In some cases, the instructor asked a specific question to initiate and focus discussion. The instructor typically got involved to clear up persistent misleading and/or confusing ideas in the discussion, or to answer direct questions. On occasion, the instructor became involved to redirect the discussion, if it was believed the students were missing the main point of the material.

Participants

Five students were enrolled in Ethics & Biotechnology. Four of them were full-time high school science teachers. The fifth was a full-time college professor. Their ages ranged from 37 to 59 with an average of 46.2. Three of the students (60%) were female. Participants had no previous web-based course experience before the bioethics courses. Three of the students stated the reason they took this course was because of continuing education, and the other two took it for enrichment and other reasons. Only one student considered herself to be beginner, two of them considered themselves to be novice, and the other two considered themselves as experts in computer experience in terms of keyboarding (word processing), using software packages, and online experience using email, Internet, gopher, etc.

Four of the students who were enrolled in the Ethics & Biotechnology course were also registered in the Ethics & Animals course. However, one of the high school teachers did not enroll in the Ethics & Animals course. In the Ethics & Animals course, students' ages ranged from 37 to 45. Three of them were full-time high school science teachers. The fourth one was a full-time college professor. The three high school teachers took this course because of continuing education and the college professor took it for enrichment. Two of the students rated their computer experience as expert, one as novice, and one as beginner in keyboarding (word processing), using software packages, and online experience using email, Internet, gopher, etc.

Research Objectives & Questions

This study was guided by the overall research objectives and the three related research questions presented in Chapter I. The objectives of the study were based on the pedagogical principles of the conceptual framework of Piaget's constructivist theory. The three research questions were designed according to the research objectives. These questions were subdivided into a series of operational questions (see Table 11). This allowed both the researcher to make the data collection and the analysis procedures were more manageable in a systematic way. The reader was able to see clear relationships between the educational principles, research objectives, research questions, and operational questions.

Table 11. Research Purposes, Questions, and Operational Questions

1st Educational Principle:
Students are active participants in constructing their own knowledge in an educational activity: Active Participation

Objective 1: To determine the nature of students' participation.
Research Question 1
Did using a Computer Conferencing System for group discussion foster active participation in the discussion activity? What was the degree and pattern of participation?

Operational questions
1. How often did course participants contribute to the CCS? (frequency)
2. How much did course participants contribute to the discussions? (amount)
3. How did the frequency and quantity of contributions change over the duration of the course? (pattern)

2nd Educational Principle:
Students learn and construct knowledge better through peer-peer interaction: Equilibrated exchanges or peer interaction

Objective 2: To examine interaction patterns among course participants.
Research Question 2
Did using the Computer Conferencing System promote interaction? What was the nature of that interaction?

Operational Questions
1. What types of interaction occurred?
2. To what degree were the contributions linked to each other?
3. What were the interaction patterns among students?

3rd Educational Principle:
Students construct knowledge through cognitive conflict resolution: Knowledge construction process

Objective 3: To examine whether or not cognitive conflicts were experienced in online discussions that led to knowledge construction. To examine the knowledge construction in online discussions by identifying indicators of knowledge construction process.
Research Question 3
Was there evidence that cognitive conflict occurs in a CCS environment? What was the nature of that conflict and how was it resolved in ways that reflect knowledge construction?

Operational Questions
1. To what extent did students' contributions to the computer conferences reflect cognitive conflict?
2. Which indicators of knowledge construction were identified in the postings? To what extent did students move though the phases of knowledge construction?
3. What was the nature of that movement?

Data Sources (Collection)

Data for this study were gathered through: 1) discussion postings, 2) field notes from non-participant observations, 3) interviews with the instructor, 4) course documentation, and 5) student survey. Discussion postings were the main data source. Other data sources were used to produce information for subsequent analysis or to triangulate data and validate information.

Discussion Postings of Computer Conferencing

The focus of this study was the online discussions, thus the transcripts of the CCS discussions, to determine the quality of the knowledge construction process. Computer conference transcripts constituted the primary data source for this study. According to Lincoln and Guba (1985), any type of written material is essentially a document that can be subjected to an analytic process. The data gathered from CCS postings enabled the researcher to obtain valuable information regarding the phenomena under investigation.

The computer conferencing system maintained a record of all computer conference messages (i.e., threads of discussion). These are a series of postings to an electronic Discussion Board that have a common subject heading. The Discussion Board provided an outline of all messages posted by author, date, and time. The messages were threaded and organized in different discussion clusters based on initiation and follow-up messages.

For each reading in a week, the instructor or students initiated a discussion by creating a heading in the WebCT Discussion Board. By clicking on the message heading, one could access the transcript of each message. As illustrated in Figure 10 (author names were covered due to confidentiality issues), “Moral Status of Animals” was one of the readings of the first week in the Ethics & Animals course. One student initiated the discussion under the heading - "Food for thought" and others made replies either to this first statement about the reading or the subsequent statements by other participants. Although discussions were initiated according to the weekly readings, some discussions lasted more than a week.

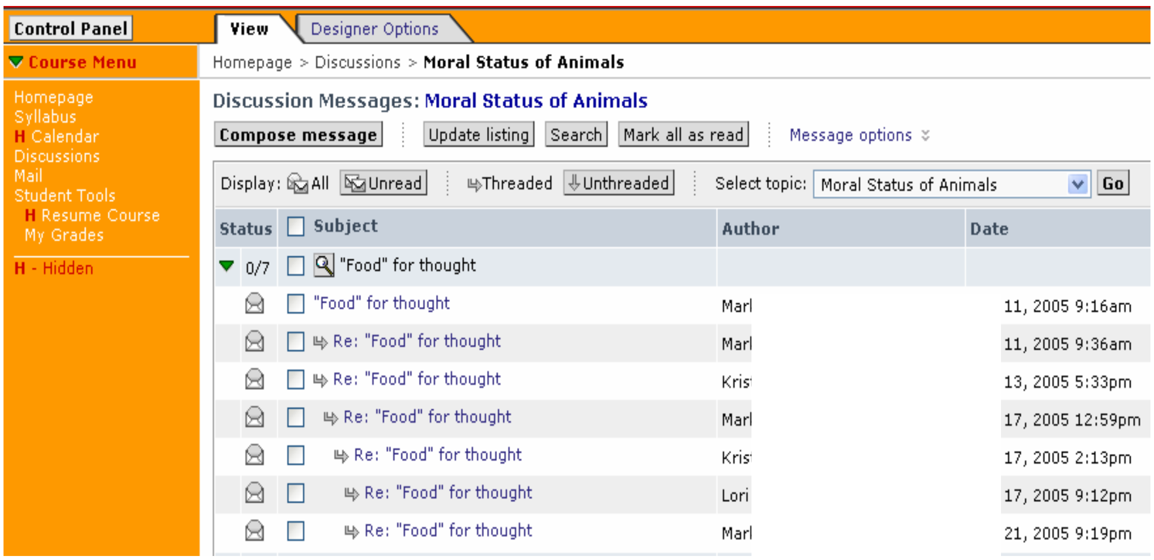


Figure 10. Sample of Discussion Board Layout

Computer conference transcripts were downloaded as a text file to a computer by the investigator. CCS transcripts were organized by chronological order and topic, read several times, and then coded and analyzed for the quality of the messages. Computer conference postings were used to gather data about:

1. Frequency and quantity of participation, for instance, number of messages posted by participants and number of times participants initiated or followed up on a discussion.
2. Thread of interactions by checking the messages whether they were directly or indirectly related to other messages, or whether they were independent messages.
3. Participation and interaction patterns.

4. Knowledge construction process of participants.

Field Notes

The CCS discussions in WebCT were monitored and field notes were taken by the researcher to gather data about the design of computer conferencing activities, the flow of interaction during discussions, and the facilitation of discussions. As part of the research process, the investigator was granted permission (by both students and the instructor) to monitor communication and interaction patterns in the discussion group postings, class activities, and the overall setting and design of the course. Therefore, the investigator was given course designer status by the instructor to allow access to all class activities. Students were also notified by the instructor about the researcher's role.

The researcher's role as a non-participant observer was to make no effort whatsoever to participate in, manipulate, or control the activities of students, but simply to observe and take notes what happened as things naturally occurred. The Discussion Board was monitored at least two times a week. Messages were read, recorded weekly, and notes were taken about ongoing discussion type, quality and activity. Some questions that emerged from these notes were used in the development of the interview questions. In summary, data gathered from the field notes provided a holistic view of the course context in which online discussions took place and were also used with other sources of data to make comparisons and to confirm emerging study findings.

Interviews

Face-to-face semi-structured interviews with the instructor (see Appendix C) were conducted to gather data about four aspects: 1) course structure and design (e.g., instructor's role and students' roles in courses, course assignments, instructional techniques, etc.), 2) participation and interaction issues in class discussions, 3) the knowledge construction process of students through discussions, and 4) the instructor's perceptions and experiences of using computer conference discussions. The transcripts of interviews assisted in the understanding of some key aspects of course design and the knowledge construction experience within the computer conferencing medium.

Interviews with the course instructor helped the researcher determine the specific discussion weeks in which more interaction and knowledge construction occurred for data sampling. Interviews were also conducted to establish confirmability of the study. These interviews took place in the course instructor's office. At the beginning of the interviews, the interviewee was informed of the purpose and general nature of the research. Initial interviews—the main focus was on collecting background information about the course—were recorded through handwritten notes. The other interviews were voice-recorded digitally and uploaded to a computer as sound files. All interviews were transcribed in a word document and stored in a computer file. The interview transcripts helped the researcher interpret the findings of the study and validate the data gathered from other sources.

Course Documentation

Course materials were used to gather data about the course and students. Course materials or public records through which the information was collected provide valuable information about the nature of the research setting and approach (Merriam, 1998). Course materials included course syllabus, assignments, and reading materials. These materials helped the researcher obtain the information about course structure and design. In brief, course documentation, as a data source, helped the researcher obtain insights about the learning environment used for description and analysis of the study.

Student Survey

An electronic survey (see Appendix D) was administered at the beginning of the Bioethics courses through WebCT. The researcher created a WebCT course site, called *Critical Thinking*, and assigned each student to that site. Within this course site, the survey was designed, using WebCT tools. Students took the survey by accessing the site using their user id and password. The purpose of the survey was to gather demographic data about students (e.g., gender, age, employment status) and their experience with using a computer and learning via a web-based course. The survey format was based on structured questions with rating scales. Survey questions were completed and obtained from all participants. Data gathered through a survey helped the researcher interpret the findings.

Data Analysis Procedures

The next section describes the quantitative and qualitative data analysis procedures used to examine participation, interaction, and the knowledge construction process, using an asynchronous computer conferencing tool. Table 12 presents the data source and analysis matrix used to address the research objectives and questions that drive this study.

Table 12. Data Source and Analysis Matrix

Research Questions	**Data Source & Data Analysis Methods**
Participation 1. How often did course participants contribute to the CCS? (frequency) 2. How much did course participants contribute to the discussions? (amount) 3. How did the frequency and quantity of contributions change over the duration of the course?	- Field notes of observations - CCS posting - Unit of Analysis is message - Descriptive statistics such as the number of student postings, frequency charts

Table 12. (continued)

Research Questions	**Data Source & Data Analysis Methods**
Interaction 1. What types of interaction occurred? 2. To what degree were the contributions linked to each other? 3. What were the interaction patterns among students?	- Field notes of observations - CCS posting - Unit of Analysis is message - Intermessage Reference Analysis - Message Map Analysis - Content Analysis
Knowledge Construction Process 1. To what extent did students' contributions to the computer conferences reflect cognitive conflict? 2. Which indicators of knowledge construction were identified in the postings? To what extent did students move though the phases of construction of knowledge? 3. What was the nature of that movement?	- CCS posting - Unit of Analysis is meaning, idea, or thought - Content Analysis

Following is a description of the data analysis procedures used to address the research objectives and questions in this study.

Participation Analysis

Computer conferencing messages were tallied for the number of postings made by each student and the instructor to determine whether students were actively participating in and contributing to class discussions. Simple descriptive statistics were used to determine the rates and patterns of weekly participation and over the duration of the activity: (a) frequency of messages posted for the length of the conference, (b) number of messages posted by each student, (c) frequency of student participation during the conference, (d) number of messages posted by instructor, and (e) distribution of discussion clusters by number of contributions made by participants. The unit of analysis for participation was the message.

Interaction Analysis

Two analytical techniques were used to analyze interaction among participants in a computer conference environment. Using these techniques, the researcher could trace the multiple threads (i.e., multiple topics being pursued together) of interaction more easily. These techniques also allowed the researcher to create clusters of interlinked messages and to extract smaller and more manageable clusters of messages for further analysis. Interaction analysis techniques such as Reference Analysis and Message Map Analysis were used to address the second research objective and questions. For the interaction analysis, unit of analysis was the message.

Reference Analysis

Intermessage Reference Analysis (IRA), as reviewed in Chapter II, allowed the researcher to determine whether any reference was made to previous messages (Levin et al., 1990). IRA was used to determine whether the messages were interlinked. Using IRA, each message was coded, based on whether reference was made to previous messages directly/explicitly, indirectly/implicitly, or whether the message included an independent statement. However, IRA provided simple surface-based information about the interactivity taking place in online discussions. The IRA technique provided no information about interaction types among participants as to whether messages were on-task or off-task referenced, or whether or not messages were course or discussion-related.

Therefore, the Intermessage Reference Analysis (Levin et al., 1990) was expanded using Howell-Richardson and Mellar's (1996) *interaction analysis technique,* which classified the illocutionary acts embodied within the messages. The interaction analysis technique (Howell-Richardson & Mellar, 1996) allowed the researcher to identify interaction linkages and types in computer conferencing.

First, the criteria to determine whether online messages were referenced explicitly or implicitly were established as follows:

- Explicit reference was determined through the participants' use of the software (WebCT Discussion Board) *comment* command, which automatically marks a message as linked to another (e.g., reply command in the conference system). Explicit reference was also determined through messages that contained explicit lexical reference to a previous message, either by the name of the previous contributor or by message number, often co-occurring (e.g., responding to…)
- Implicit reference was determined through lexical cohesive reference to a topic through exact repetition of key lexical items occurring in previous messages or use of a synonym (Howell-Richardson & Mellar, 1996)

The first criterion was sufficient to establish evidence of linkage or reference. However, the second criterion was determined through a linguistic analysis by tracing the pattern of lexical cohesion among messages. All messages were read and coded, based on these criteria to determine interaction linkages. Interactivity was established by whether the messages in a discussion cluster linked to other messages. Independent messages in a discussion with no link to previous messages were coded as monologue messages.

Second, to identify interaction types (on-task or off-task) between messages, a coding scheme classified by the illocutionary act was used in this study. Table 13 presents the coding scheme with its indicators and their definitions for task-related messages. All messages were read several times, coded and grouped in discussion clusters, which were defined by messages that linked or related to the same topic and/or referred to other contributions. Messages that did not indicate any task-related statement were coded as off-task.

Table 13. On-task and Off-task Interactions (Howell-Richardson & Mellar, 1996)

Indicator	**Definition**
Initiate/Propose	Initiates/suggests/proposes a new thread of discussion or a new interpretation
Reject/Disagree	Expresses disagreement with a statement made by a previous speaker
Confirm/Elaborate	Confirms through elaboration or development either a topic an idea or an interpretation of the topic presented in an earlier message and/or by a different contributor
Refer to External Resources	External resources are taken as sources not contained within the conference itself
Summarize	A summary of one theme from previous discussion by one or more contributors
Request	A request for clarification, information or elaboration – usually addressed to an individual

Message Map Analysis

Message Map Analysis provides a powerful outcome of reference analysis (Levin et al., 1990). Message maps provide a visual representation of the online messages by visualizing the sequence of interaction of participants across time. The message map allows one to graphically identify who initiates a topic, whose messages are referred to frequently, and who participated frequently in or followed up the discussion. In their message map analysis, Levin et al. (1990) represented each message by rounded rectangles. They used arrows for links between messages, time (in weeks) as the horizontal axis, and contributor of the message as the vertical axis.

Levin et al.'s (1990) message map analysis technique was used to determine and examine interaction patterns with some modifications in this study. Instead of the clusters named by title or header of the message initiating the discussion, numbers inside parenthesis were used to identify the clusters of interaction. This study used numbers assigned for each student and the letter "I" for the instructor participating in the discussion, circles to represent the initiation message, and squares to represent follow-up contributions. Moreover, arrows were used to show links between messages and the horizontal axis to represent length of the course in terms of dates (see Figure 11).

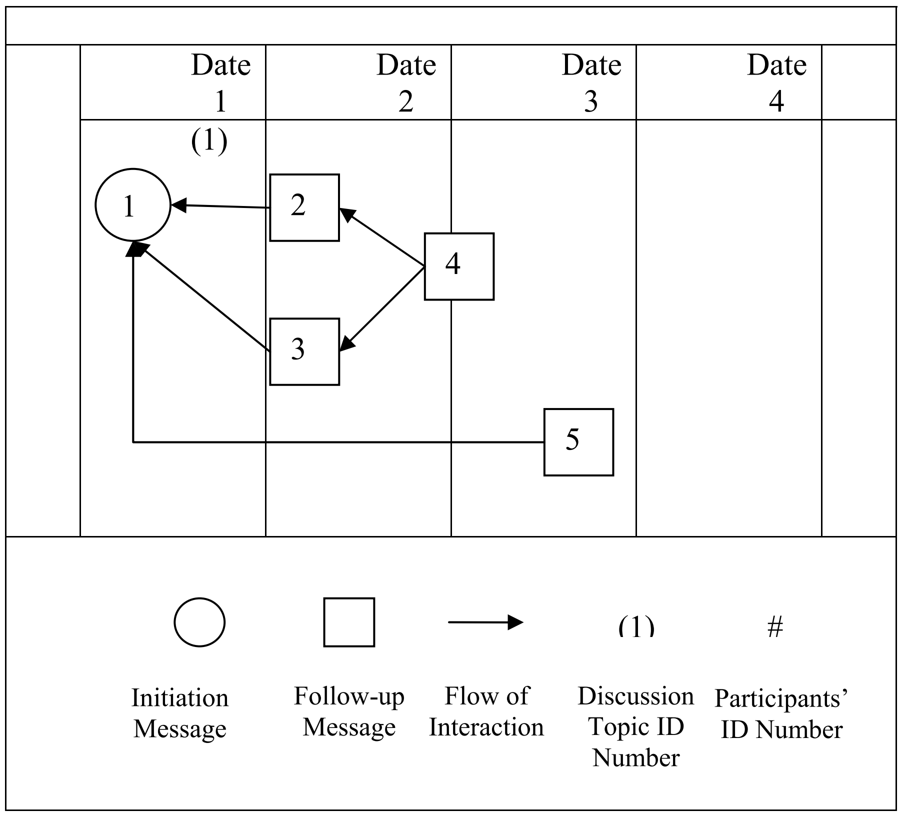


Figure 11. An Example of Message Map

Message map analysis technique was used to identify clusters, sequence, and patterns of interactions through graphic representations across time (i.e., days). Each message was analyzed for a relationship between messages posted by participants. Each message was tabulated as either referenced or independent. Messages that explicitly or implicitly referred to previous messages were tabulated as follow-up messages. In addition, discussion clusters representing a complicated web of interactions such as stair-like or star-like interactions (see

Figure 12) were presented through graphical representations of these patterns of interactions.

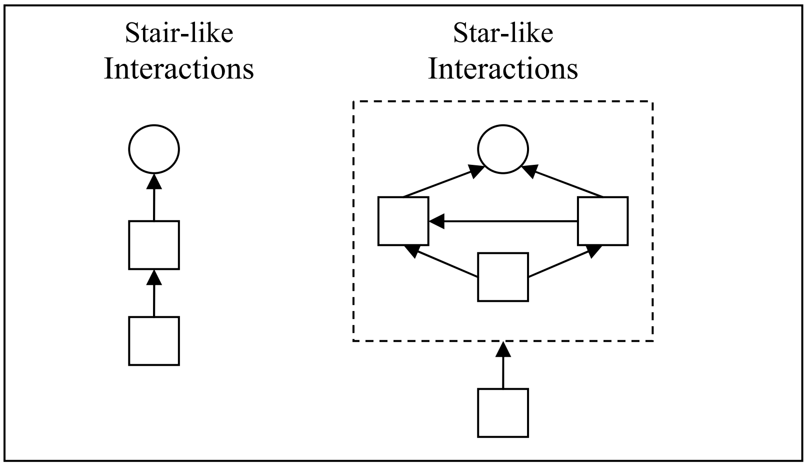


Figure 12. Interaction Patterns

Content Analysis

Content analysis is defined as a "research methodology that utilizes a set of procedures to make valid inferences from text. These inferences are about the sender(s) of message, the message itself, or the audience of the message" (Weber, 1985, p. 9). Content analysis can be used to determine and examine the content of written, recorded, or published communications through a set of procedures for collecting and organizing information that allows researchers to draw inferences about the characteristics and meaning of the content. In other words, content analysis recognizes the inferential character of coding textual units into conceptual categories systematically and objectively (Krippendorff, 1980).

Content analysis historically has been used as a quantitative tool. Many scholars have agreed that content analysis provides systematic examination of the manifest content of communication (Berelson, 1952) to mainly focus on numerical descriptions of some features of the text, such as frequency and variety of messages. Others, such as Osgood (1959), argue that content analysis facilitates unobtrusive measurement. Content analysis can provide an explanation of latent content of messages to qualitatively analyze thematic expositions and recurring patterns of context-based meaning. Qualitative content analysis gives considerable thought to communication of meaning and to "the 'kinds', 'qualities' and 'distinctions' in the text before any quantification takes place" (Bauer, 2000, p. 132). Therefore, content analysis is a hybrid technique that bridges quantitative or statistical formalism and the qualitative analysis of the materials (Bauer, 2000).

The inherent attributes of CCS lend themselves particularly well to the content analysis of the discourse displayed in conference transcripts. Because of its capability to trace, record, and display online messages, CMC tools, especially CCS, provide a rich source of data and an ideal context for examining and developing a better understanding of online learning.

Because one of the research objectives of this study was to examine the quality of learning in terms of the knowledge construction process in online discussions, content analysis was selected as a data analysis technique. Content analysis was used to assess the degree to which student message units appeared to reflect the knowledge construction process in the computer conference discussions. The content analysis procedure will now be described as used for this study.

Unit of Analysis (UoA)

Prior to conducting content analysis, it is important to determine the basic unit of text to be analyzed. Some researchers claim that a message as a whole embodies a participant's cognitive activity and contribution to the construction of knowledge. Thus, the '*complete message*' in a discussion forum was generally used as the unit of analysis. However, the unit of message did not fit in this study because some messages contained very little information;

others contained three or more distinct ideas, comments, complex arguments or hypotheses, addressing different concepts or questions raised during the discussions.

Sometimes, a message could include one or more of the knowledge construction categories reflecting the cognitive development process of the participant displayed in the text. Therefore, the basic unit of analysis for the content analysis was "thematic" or "meaning" for this study. Henri (1992) advocates this type of unit of analysis by arguing that "it is absolutely useless to wonder if it is the word, the proposition, the sentence or the paragraph which is the proper unit of meaning, for the unit of meaning is lodged in meaning" (p. 134). The entire text of the sample messages was analyzed, based on the unit of meaning, idea, or thought as expressed in this study.

Category System and Coding Scheme

The content of the computer conferences was analyzed, based on Gunawardena et al.'s (1997) coding scheme of the five-phase constructivist interaction analysis model for evidence of the knowledge construction. It may be recalled from Chapter II-literature review, the five hierarchical phases of Gunawardena et al.'s (1997) model (see Table 2 in Chapter II) were:

Phase I - Sharing/Comparing of Information

Phase II - Discovery & Exploration of Dissonance or Inconsistency among Ideas, Concepts or Statements

Phase III - Negotiation of Meaning/Co-Construction of Knowledge

Phase IV - Testing and modification of proposed synthesis or co-construction

Phase V - Agreement statement(s)/applications of newly-constructed meaning

Gunawardena et al's. (1997) coding scheme was selected to conduct content analysis for three reasons. First, this scheme with operational indicators and definitions of each phase was the most complete and straightforward scheme for the context to be examined—a computer conference as a major medium of a professional graduate level course for knowledge construction. Second, the underlying constructivist framework of Gunawardena et al.'s (1997) model was strongly consistent with the bioethics courses, which were based on constructivist learning principles for student-centered learning emerging from a computer conference:

> The computer conferencing tool was used as it is "effective in getting people to express their views about [course] material, so doing some critical work so that they are not passive receivers….[computer conferencing is] making students more active participants….a successful knowledge construction would have to involve very least understanding the ethical problem that they [students] are dealing with, understanding ethical resources for addressing the problem, and then at least having thoughts and appreciated how to apply some of those tools to problem they chose to create a solution. So, the idea is, I mean, they don't have to walk away with writing answers…if they've engaged in the Discussion Board, especially, if they've responded to their fellow students, …, that is what is going to stay with them more durable, they are going to own it more reflectively as opposed to some interesting fact they picked up in the reading, …and it's especially important since the point in my classes is to think about ethics not just to learn facts or do arithmetic… So when we have good discussion going on, I actually feel that's essential to their constructing any knowledge at all" (K. Hessler, personal communication, March 31, 2006).

Third, since Gunawardena et al.'s (1997) coding scheme was specifically developed and designed for adult and professional learners, it was fitting for this research context. All participants were K-12 or higher education teachers.

The coding scheme, based on the five-phase category system of Gunawardena et al.'s framework, along with their operational activities and definitions, was adapted and imported within Atlas.ti 4.2, a computer-assisted qualitative data analysis package.

Document Selection and Sampling

From a total of 133 messages generated by the students in the two online discourses, only discussions for one specific week for each course were analyzed (see Table 14). Discussion transcripts of Ethics & Biotechnology (Week 2) and of Ethics & Animals (Week 3) were chosen for analysis.

Table 14. Sampling

Course	Week #	Technology Used	Discussion Format	Number of Messages
Ethics & Biotechnology	2	WebCT threaded conferencing tool	Free, open-ended	29
Ethics & Animals	3	WebCT threaded conferencing tool	Free, open-ended	21
			Total :	50

These two weeks were selected as sampling data, due to their learning objectives and content that encourages students to critically think, understand, discuss, and construct knowledge about ethics issues. In addition, these weeks were selected because they targeted the comprehension process of students' about course topics. For instance, as stated in course syllabus of Ethics & Biotechnology, the learning objective was:

> After this unit, you will better understand: various applications of biotechnology in agriculture; the various controversies about agricultural biotechnology; distinct

ethical arguments about agricultural biotechnology; your own views about one specific product of biotechnology, golden rice. (Appendix A)

The selected samples included course-related discussion threads initiated during specified weeks. Messages posted in the following weeks were also included in the analysis procedure, if they were part of the preceding discussions.

Coding Process

Before the coding process began, all student names were replaced with pseudonyms to assure confidentiality. All conference transcripts of the sample data were downloaded from WebCT environment as text files and imported in the Atlas.ti 4.2 environment. All transcript data were read numerous times to obtain a sense of the types and the levels of interaction and knowledge construction processes exhibited by participants in the computer conference.

The following procedures were followed for the coding process. First, a pilot study was conducted to assess the effectiveness of the coding scheme used for the present study. The coding scheme was tested in a pilot study that explored the dynamics of a learning community at a graduate level, 14-week course, facilitated by a computer-mediated conference in terms of two main concern areas: 1) interaction patterns and 2) knowledge construction through social negotiation among students. As a result, a coding scheme based on the Interaction Analysis Model by Gunawardena et al. (1997) was found effective to investigate evidence of knowledge construction in a computer conferencing setting.

Second, for the present study, the complete set of electronic transcripts of online discussions were read and analyzed by the primary coder on three separate occasions to validate the coding procedure. To establish reliability, two other coders analyzed a portion of the data (10% of the total) independently with the goal of reaching 80% final inter-coder or inter-rater agreement. These two coders were research assistants at an accredited university, who had experience in qualitative research, and who had published journal papers especially related to the online discussions through computer-mediated communication. Before the two coders worked on the coding process, descriptive rules about the coding scheme along with examples were explained by the primary coder (the investigator of the study) to them in a training session.

When disagreement occurred among coders after having coded the data, a discussion was held to reach a consensus on how to code the segment, and modifications with the descriptive rules of coding scheme, if necessary, were made to resolve ambiguities. Transcripts were re-coded by the researcher after the inter-rater agreement was reached at 80% on the sample data. After all the transcripts were coded, the researcher searched for the coded segments to determine the degree and type which participants interact with each other and construct knowledge.

Validity and Reliability

Validity

Guba and Lincoln (1989) state that validity refers to "the isomorphism between constructed realities of respondents and the reconstructions attributed to them" (p. 237). Validity is simply concerned with the accuracy, appropriateness, meaningfulness, and applicability of the specific inferences that researchers make, based on their data (Merriam, 1998). Techniques used for internal validity and external validity are explained as follows.

Internal validity, or credibility, was established in this study through triangulation of data sources—transcripts of online messages by participants, field notes via non-participant observation, course documentation, interview transcripts, and survey responses. Triangulation was also established by utilizing a conceptual framework for data analysis procedures, such as participation analysis, interaction analysis, and content analysis. The multiple levels of analysis to answer the research questions strengthened the validity of the study. Findings from the analysis procedures were triangulated with other data sources in the study.

Credibility was also addressed through techniques such as peer debriefing and researcher journaling (Merriam, 1998). A peer debriefing, or peer review, is the review of the research process by someone who is familiar with the research being investigated (Creswell & Miller, 2000). A peer reviewer is a person who provides support, suggests different frameworks for analyzing the data, challenges the researcher's assumptions, and pushes the researcher to the next step methodologically (Guba &Lincoln, 1989). The dissertation advisor was the peer reviewer in this study.

Researcher journaling was another strategy used to establish credibility. A journal was kept as a record of the researcher's thinking during the data analysis procedures (e.g., by writing notes/memos during content analysis in regard to emerging concepts and ideas). Researcher journaling allowed the researcher to explain how conclusions were drawn and interpretations were made.

External validity, or transferability, refers the extent to which the study can be applied to other contexts. External validity is concerned with the generalization of research findings to similar settings being studied. However, external validity in terms of generalizing results, especially from an interpretative study, is very difficult (Guba &Lincoln, 1989). The major strategy for establishing the degree of external validity is through 'thick descriptions' by providing as much detail as possible about the setting, the participants, and the themes or culture of the research situation (Merriam, 1998). Therefore, external validity was addressed in this study by providing thick descriptions of the research environment to allow others to decide if the findings are applicable to similar settings.

Reliability

Reliability, or dependability, in the traditional sense is concerned with the accuracy of data that remain constant over time so research findings can be replicated. Reliability evaluates "the extent to which any research design, any part thereof, and any data resulting from them represent variations in real phenomena, rather than the extraneous circumstances of measurement, the hidden idiosyncrasies of individual analysts, and surreptitious biases of a procedure" (Krippendorff, 1980, p. 129).

Reliability was addressed in this study by three methods. First, a pilot study was conducted to examine the dependability of the coding scheme. Second, an inter-rater reliability procedure for this study was employed to establish reliability. And finally, different methods of data collection and analysis were used (triangulation).

Confirmability

Confirmability, or objectivity, is important because interpretations and conclusions reached by the researcher should be based on the data collected rather than a researcher's reflection, imagination, or bias. Since the course instructor was the subject-matter expert and course designer, the researcher took sample excerpts from the raw data that support interpretations and conclusions back to the instructor in the study for verification of the credibility of the information. The researcher asked the course instructor to review the raw data, and make comment on their accuracy, based on whether the themes or categories of coding scheme assigned to unit of analyses made sense, and whether they were developed with sufficient evidence.

CHAPTER IV: FINDINGS AND DISCUSSION

This chapter is divided into three sections that introduce and discuss the findings of the study. Each section addresses a specific research objective and the corresponding question based on the theoretical framework of this study (see Chapter II). The first section presents and discusses the findings related to the participation in computer conferencing. The second section reports and discusses the findings related to interaction. And the third section reports the findings related to the knowledge construction process in online discussions. Finally, the findings related to each section were summarized.

Part I: Participation

This section examines the nature of students' participation in an asynchronous computer conferencing. Specifically, this section determines whether a computer conferencing system for group discussion fosters active participation in the discussion activity in terms of the degree and pattern of participation.

Quantitative measures of participation in the computer conferences were taken, including (a) the amount of participation throughout the course, (b) the frequency of participation, and (c) participation pattern over time. These quantitative measures were tracked over time to see if they changed over the duration of the courses. Qualitative measures were also taken by reading all messages and selecting those that were task-related. As described in Chapter III, the messages by participants, which are task-related or course-related were included in this study (i.e., the messages that were constituted of only social cues, for instance, "Thanks for sharing. What great students you have!" were not counted).

Findings

Amount of Participation

The total number of messages posted by participants (instructor and students) was 73 for the course—Ethics & Biotechnology (C1) and 58 for the course—Ethics & Animals (C2) (see Table 15). Of this total, 62 (an average of 12.4 messages) for C1 and 46 (an average of 11.5 messages) for C2 were student postings (see Table 15). And, 15.1% of the total number of messages in the online discussions (11 out of 73) in C1 and 20.7% of the total number of messages (12 out of 58) in C2 were instructor messages (see Table 15).

The average number of messages posted per week per student for C1 was just over four messages (4.1) and for C2 was approximately four messages (3.9). This means that, on average, each student posted four messages per week (three messages per student per week was a requirement of both courses).

Table 15. Course Participation

Week/ Course	Total # of messages	Total # of student messages	Total # of instructor messages	Mean messages per student	% of messages by students	% of messages by instructor
W1/C1	21	16	5	3.2	76.2	23.8
W2/C1	29	26	3	5.2	89.7	10.3
W3/C1	23	20	3	4	87.0	13.0
Total(C1)	73	62	11	12.4	84.9	15.1
W1/C2	27	21	6	5.3	77.8	22.2
W2/C2	10	8	2	2	80.0	20.0
W3/C2	21	17	4	4.3	81.0	19.0
Total(C2)	58	46	12	11.5	79.3	20.7

The amount of student participation varied over three weeks for the two courses. Sometimes, a certain week showed either an increase or a decrease in contribution by students compared to others. An interesting finding was the amount of participation each week in one course seemed to balance the amount of participation in an associated week in the other course (see Table 16). Some students participated with the same frequency in specific weeks, and some distributed their efforts for participation over the duration of each course as well as between the two courses.

Table 16. The amount of student participation per week in both courses

Course	Week1 # of messages	Week2 # of messages	Week3 # of messages
C1	16	26	20
C2	21	8	17
Total	37	34	37

The total number of messages posted per week by students in C1 varied from 16 to 26. In the C2 course, the total number of messages posted per week by students varied from 8 to 21. The amount of student participation began climbing after week 1 and reached its peak during week 2 in the course C1 (an average of 5.2 messages per participant) (see Figure 13). Then, the number of messages after week 2 tended to decline in week 3 to 20 messages (an average of 4 messages per student). In C2, the majority of the participation took place in the first week (an average of 5.3 messages per student). Afterwards, the number of messages showed a precipitant decline during week 2, and then an increase in participation during week 3 in which 17 messages (an average of 4.3 messages per student) were posted.

Figure 13 also illustrates the instructor's participation showed a similar pattern in both courses. Participation by the instructor hit the highest point in the first weeks of both courses (5 messages in C1, 6 messages in C2) and then showed a decline during the following week. After this, the number of messages by the instructor remained the same in C1 and showed a small increase in C2 (4 messages) during week 3.

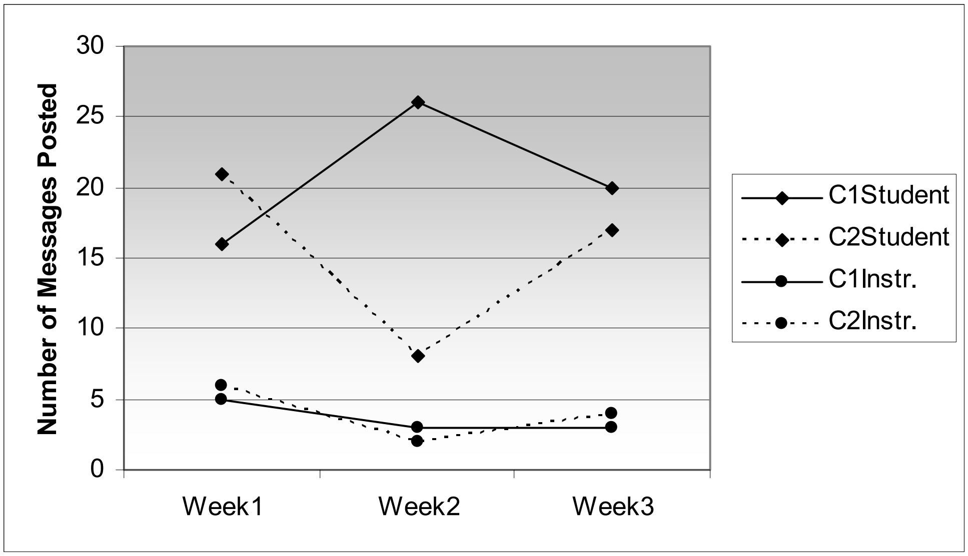


Figure 13. Weekly Online Contribution

Frequency of Participation

Overall, participation by students in the computer conferencing of the two courses—C1 and C2—seemed to fulfill the requirement of three postings per week per student, 9 messages minimum. However, contribution to online discussions was not evenly proportioned among the students. Especially in course C1, one student (Tracy) did not participate at all in task-related or content-related discussions, but posted only social-related messages (e.g., introducing herself, welcoming others) (see Figure 14). Other students contributed to online discussions by posting over 9 messages throughout the course. In C1, John and Mary were the two most active students (18 messages each) in computer conferences overall. Diane (registered only in C1) followed John and Mary with 15 messages.

As Figure 14 shows, in course C2 all students exceeded the minimum participation requirement. Students were quite active in online discussions. John, as in C1, was the leading student in contributing to computer conferencing. In C2, the total participation made by the course instructor to online discussions (12 messages) was significant, compared to the number of contributions made by the students (an average of 11.5 messages per student).

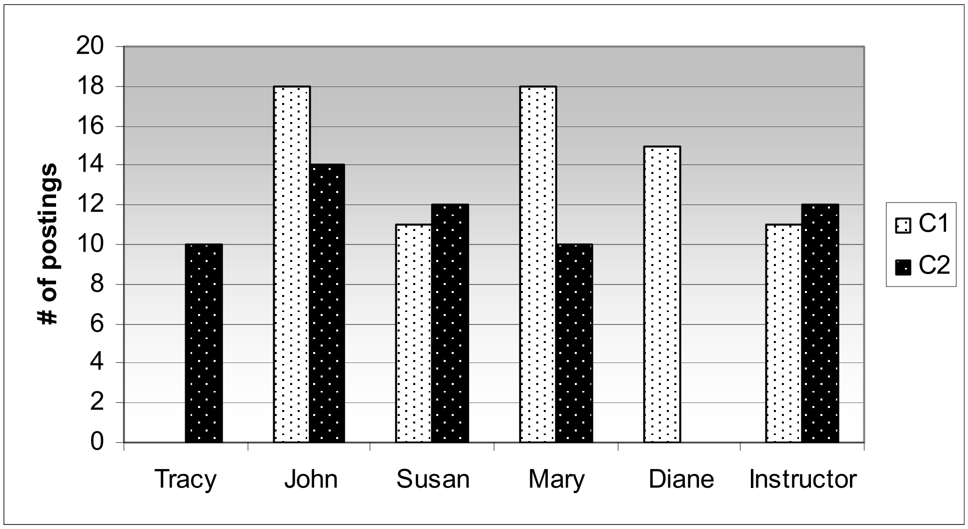


Figure 14. Frequency of task-related contributions

Participation Pattern

For C1, all course participants, but Tracy, contributed to the discussions regularly throughout the course (see Figure 15). Week 2 had the highest contribution rate in total (29 messages); whereas, week 1 had the lowest rate (21 messages). Some students (Susan and Diane) tended to increase their participation during each week and reached their peak during the last week of the class (see Figure 15). In contrast, some students (John and Mary—the two students who were the most active participants over time) showed a sharp decrease in their participation during the last week (see Figure 15). Those students, however, made a large number of contributions to online discussions during the first two weeks of the course, where week 2 was their more productive stage in terms of participation (see Figure 15).

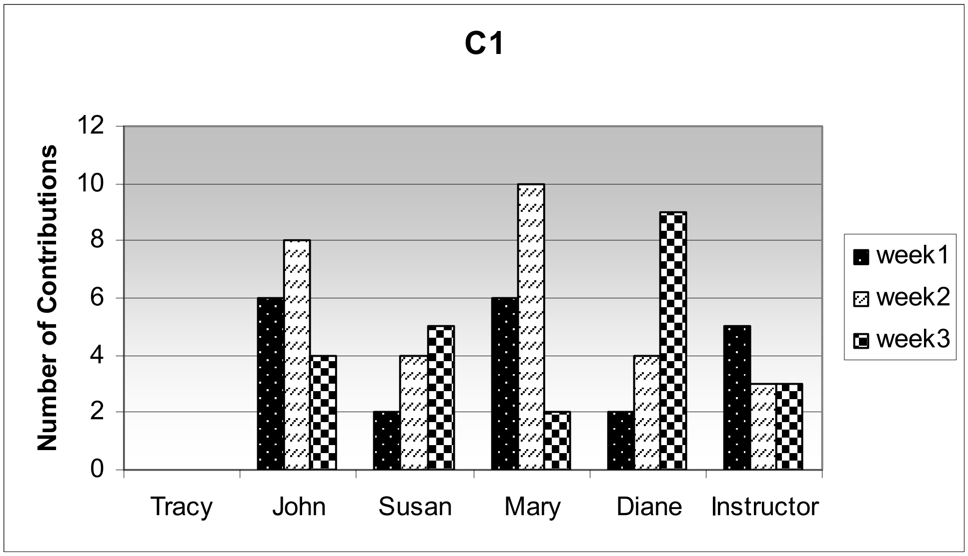


Figure 15. Participation pattern in C1

For C2, all course participants contributed to the discussions regularly throughout the course (see Figure 16). The first week of the course revealed the highest contribution rate with a total of 27 messages. During the following week, students' participation tended to decline quite quickly, bottoming out in week 2 at 10 messages, and then climbing to 22 messages in week 3 (see Figure 16). As Figure 16 shows, 4 out of 5 participants, including the instructor, were very active during the first week. On the other hand, they were unable to keep their activity at that level during the following week. Students' contributions did not exceed the minimum participation requirement during week 2 (two messages per student). Then, during week 3, participants generally tended to increase their contributions. Tracy, especially, who had been an inactive student for the first two weeks, attempted to make a considerable amount of contributions in the last week compared to others. This increase could be due to the requirement for participation within the course.

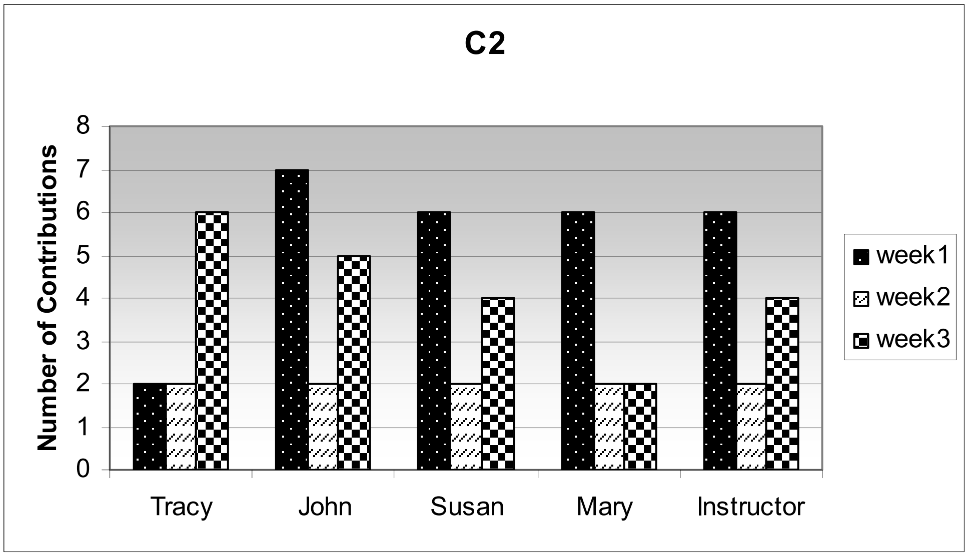


Figure 16. Participation pattern in C2

Discussion

Participation among students in both Bioethics courses was found as moderate. Although participation in online discussions—counted for 60 % of the students' final grades—was essential for learning objectives of these courses, students participated only with an average of four messages per student per week, where three messages per week was a minimum participation requirement.

Students' experiences and attitudes in these online courses seemed to have an impact on the participation level found in this study. Some students were more active participants than others. John, for instance, dominated some discussions by starting topics and acting like an instructor by replying and providing answers to others' comments or questions. This could be due to John's experience in online teaching. Although, he had not taken any online courses as a student before the bioethics courses, he had taught several college level online courses. Hence, he was experienced in providing feedback and writing comments about others' postings.

In addition, some students chose to log on and read messages more frequently than they logged on and posted messages, that is, they acted as lurkers. For instance, Tracy, who did not post any task-related messages in C1, visited the content pages 12 times; and another student, Jerry, visited the content pages 57 times, read others' messages 86 times, but only posted 11 messages in C1.

The instructor's approach to organizing and moderating the discussions also appeared to have an impact on students' contributions to online discussions. The instructor tried several approaches to promote and encourage online participation in discussions. As the instructor explained,

> Students are expected to respond to the course material from their own perspectives in discussion. In some cases, this is open-ended and students are simply expected to share their first reactions to the material (e.g., Bloggs cases). In other cases, I will ask a specific question to focus discussion. I tend to get involved mainly to clear up persistent confusions in the discussion or to answer direct questions. On occasion I'll get involved to redirect discussion if I feel the students are missing the main point of the material (K. Hessler, personal communication, March 14, 2006).

In order to initiate a discussion, the instructor usually asked questions and requested students to reply and provide their own opinions. However, the type of the question may have had an impact on student participation. For instance, the total number of contributions by students to computer conferencing in week 2 of the course—Ethics & Biology (C1) (26 messages) was more than three times the quantity of participation by students in computer conferencing in week 2 of the course—Ethics & Animals (C2) (8 messages).

In C1, the instructor asked the following question related to a case study to initiate the discussion, “If we had to write a collective to the Rockefeller Foundation, either supporting or opposing their funding of golden rice research, what would you want the letter to say? Use one of your required postings this week to tell the group whether you think we should support or oppose Rockefeller funding for golden rice, and why.” In C2, the instructor also asked the following question related to a different case study to initiate the discussion, “Discuss your views in the Discussion Board called Sow Confinements.” There is clearly a difference between those two questions in quality and in encouraging students to contribute to computer conferencing.

The question in C1 was focused and direct about what the instructor wanted the students to discuss. It requires the ability to grasp the meaning of the information, to analyze and synthesize it, and to judge the value of the information. The question in C2 was broad, and there was no clearly established topic or focal point, which caused overwhelmingly independent messages. Therefore, students posted their opinions and left the discussion area. They did not see it necessary to reply to others’ comments which lacked or contained little comprehension, analysis, synthesis, or evaluation of the information.

Additionally, the organization of the course content seemed to influence students’ participation in discussions. The amount of participation in a discussion appeared to be low, where the content to be discussed was provided with numerous hyperlinks to outside web pages. Students had to read a lot of information found on different web pages, provide their opinions about these, and then discuss the issues with their classmates. However, this could have prevented students from discussing their viewpoints on a specific issue or topic, thus their participation.

Participation is a key factor in developing an interactive and ongoing community in constructing knowledge in a computer conferencing network. The remaining sections of this chapter address interaction and knowledge construction in computer conferencing by focusing on specific weeks of each Bioethics course—week 2 in Ethics & Biotechnology (C1) and week 3 in Ethics & Animals (C2)—as explained in Chapter III.

Part II: Interaction

As reviewed in Chapter II, interaction is a critical ingredient for effective learning and knowledge construction (Brookfield, 1986; Slavin, 1983). The attributes of CCS create a shared space, a mutually supportive collaborative environment in which peer-to-peer interaction is encouraged, with the opportunity to reflect on alternative perspectives, propositions, and insights. Computer conferencing allows learners to compare, discuss, modify, and identify new perspectives (Harasim, 1990) by communicating with each other,and at the same time allowing active interaction among those communicating (Mason & Kaye, 1990).

This section addresses the second research objective of this study—to examine interaction among course participants in a computer conferencing system. More specifically, this section scrutinizes whether using a computer conferencing system promotes active interaction.

Findings

Interaction Types

In Chapter III, interaction was defined based on two types of messages—independent and interactive. Independent messages, or monologue messages, are those messages in a discussion with no explicit or implicit link to any other messages. Interactive messages are those that were established by whether the messages in a discussion cluster linked to other messages, by responding to them, elaborating on them, or building on them in some mode.

To determine the type of interaction, a discourse analysis was conducted by tracing the pattern of lexical cohesion among messages. All messages were read and coded to establish evidence of interaction. This was an imperative process, due to the fact that students, unlike experienced online participants, appeared to be unfamiliar with how to use the technological features of the discussion area within WebCT. For instance, rather than using the reply function to post a reply to a message, students usually utilized the function of posting a new message that creates a new discussion topic or cluster. Therefore, their messages seemed like an independent or a monologue message. In this case, discourse analysis assisted in identifying links between those messages.

The analysis showed that all messages by participants were interactive messages. That is, all messages were linked to one or more messages explicitly or implicitly. These findings provided initial information regarding interaction types (interactive or independent). Therefore, interaction analysis technique (Howell-Richardson & Mellar, 1996) was also conducted to determine the types of interaction among participants in terms of whether messages were on-task or off-task referenced, or discussion-related. All messages were reread and recoded to determine six interaction types based on the interaction analysis technique: 1) Confirm/Elaborate, 2) Initiate/Propose, 3) Refer to External Resources, 4) Reject/Disagree, 5) Summarize, and 6) Request (see Table 13 in Chapter III).

Type of interaction by students.

The results revealed three types of interactions that dominated the interaction among students in C1 during week 2 (see Table 17): 1) *confirmation* through elaboration or development of either a topic, an idea or an interpretation presented in an earlier message by a different contributor (32.2% of the messages), 2) *initiation or suggestion or proposition* of a new thread of discussion or a new interpretation (38%), and 3) *providing and referring to external resources* taken as sources not contained within the conference itself (23.4%).

In addition to these, three other interaction types were found in students' messages—one message revealed interactivity through *summarizing* of one theme from a previous discussion; and two messages consisted of a *request* for clarification, information, or elaboration.

Table 17. On-task Interaction Types

Interaction Types	Students: Total # of messages based on interaction type		Students: % of interaction type among messages posted by students	
	C1	C2	C1	C2
Confirm/Elaborate	15	12	32.2	60
Initiate/Propose	18	6	38	30
Refer to External Resources	11	1	23.4	5
Reject/Disagree	0	0	0	0
Summarize	1	0	2.2	0
Request	2	1	4.2	5
Total	47	20	100	100

Similar to the findings in C1, interaction among students in C2 usually took place through two types of interaction. Over half of the interactions in C2 occurred through *confirmation and elaboration* of a discussion topic, an idea, or an interpretation posted by others (see Table 17). *Initiation and proposition* of a new topic or interpretation was another common type of interaction that occurred among participants in computer conferencing.

These two types of interactions outweighed the other types of interactions in online discussions, such as *referring to external resources*, and *requesting* clarification or elaboration from others, which were utilized by participants only once. And, there was no evidence found that participants exhibited expressions about a *disagreement* with a statement posted by others as well as a *summary* of one issue or theme from previous postings by one or more contributors.

In the following message, a student (Mary), for instance, confirmed and elaborated the benefits of biotechnology in human life by replying to the example given by the instructor. This student elaborated on the topic by providing examples as well as her own interpretation.

> Again, this is a wonderful, positive example of how biotechnology can better the life of people. Biotechnology is scary for any population that doesn't understand the science behind it. We have grown up with science fiction movies, the National Enquirer, and a fascination for mutations. (Ripley's "Believe It or Not" comes to mind!) We need to remember that there are still people living that do not believe that we went to the moon! I believe that introducing an essential vitamin to a diet internally through GMO's makes more sense than pills. I hope we can someday do the same for vaccinations! Eat an apple-prevent measles. How cool would that be? People have had fears about microwave ovens when they were first introduced and the skeptics are always out there to keep us on our toes!
>
> The only reason I can see the skeptics side of concern is when the FDA approves a product like saccharin or food coloring #xyz and it does prove to be cancerous. I suppose there is a risk in everything (Mary, C1, Discussion Topic #3).

Students also initiated new topics by asking questions or proposing new interpretations. The following message included an *initiate/propose* type of interaction by a student. This student (Susan), first, provided her view and interpretation about an ethical debate that was pointed out by the instructor. Then, she used questions in an attempt to initiate a new discussion.

> I think that especially today the labs are regulated and watched much more closely than years before. Can you imagine how poorly treated animals and humans for that matter were treated in the years past before they were watched and had to answer to the government etc? Especially the mentally retarded or insane had to suffer.
>
> I don't approve of the people given the hepatitis strain. And how can it be justified that the people signed a release when they didn't do what they said that they were going to do. Speaking as a stepmother to a mentally retarded child I can't imagine Tonja being put through this inhumane treatment.
>
> So how do I decide where the line is? When is it okay to use animals and for what? … (Susan, C2, Discussion Topic #2)

According to content analysis of messages, some messages posted by students contained multiple interaction types. As explained in Chapter III, the unit of analysis for interaction types was the whole message. Messages containing statements that reflect different interaction types were coded, based on those interaction types. For instance, in the following example, this student *referred to an external source* by making a citation after he agreed with the previous statement by another student. Then, he tried to *initiate a new topic* by means of *asking questions*.

I tend to agree with you. However I also like the caveat issued by the Center for Food Safety.

'CFS seeks to halt the approval, commercialization or release of any new genetically engineered crops until they have been thoroughly tested and found safe for human health and the environment. CFS maintains that any foods that already contain genetically engineered ingredients must be clearly labeled. Additionally, CFS advocates the containment and reduction of existing genetically engineered crops.'

I believe that if that were followed, then we would be on our way to feeding the world. However, how long will this take? When is something finally considered to be "safe?" (John, C1, Discussion Topic #3)

Type of interactions by the instructor.

Online messages in discussion clusters were also read and analyzed for the type of interactions by the instructor in the class that might have an effect on the flow and quality of discussions. Findings revealed that messages posted by the instructor, akin to student postings, contained mainly two types of interactions—confirmation/elaboration and initiation/proposition. Typically, messages that initiated or proposed a new topic constituted the majority of the instructor's messages. For example, the course instructor in the following posting asked some questions to start a discussion topic and requested students to answer those.

What do you think of the debate about biotechnology and world hunger? [See the last section on the page on ethics & biotechnology for this week.]

> For example, Bruce Chassy wrote: "While agricultural biotechnology is not a panacea to food insecurity, it is likely to play a vital role in the delivery of food assistance and reduction of hunger for generations to come."
>
> Is this true, do you think? Why or why not? (Instructor, C1, Discussion Topic #2)

In addition to initiating messages, the instructor interacted with others by *confirming* or *elaborating* on prior statement(s) to provide additional information, perspective, or interpretation. The following message by the instructor is an example of this type of interaction.

> I was disturbed by the description of this experiment as well. I am trying to decide if it makes a difference what animal is used. I think I agree with John's assessment that the experiment is cruel and possibly not justifiable by Federal standards, but I am wondering if there are any animals out there on which such an experiment would not be cruel. A frog, maybe? I guess I still think it would be cruel. (Instructor, C2, Discussion Topic #2)

Intermessage References

The intermessage reference method was used to trace multiple threads of interactions to determine whether messages made reference to previous messages and the degree to which the contributions linked or referenced. Table 18 shows the number of times messages were referenced by other messages in both C1 and C2. As can be observed, half of the total messages in online discussions were not referenced. On the other hand, a few messages were referenced multiple times (one message was referenced by nine other messages in C1; one message was referenced by five times in C2, etc.).

Initiation messages by the instructor were referenced more than any other messages. For instance, in C1, the initiation message in a discussion cluster by the instructor was referenced nine times (see Table 18). This could be due to students tending to reply to the instructor's comments or questions rather than interacting with peers. This is very similar to an interaction in a face-to-face classroom where the instructor is the authority, and the main interaction takes place between the instructor and students (Harasim, 1995). Perhaps because students in this study were inexperienced online learners, they fell back on familiar traditional classroom interaction patterns.

Table 18. Number of Times Messages Referenced by Other Messages

C1			C2		
# of references	# of messages	% of messages	# of references	# of messages	% of messages
9	1	3	9	0	0
8	0	0	8	0	0
7	0	0	7	0	0
6	0	0	6	0	0
5	1	3	5	1	5
4	0	0	4	0	0
3	0	0	3	2	9
2	0	0	2	1	5
1	11	38	1	6	27
0	16	55	0	10	45

The findings also showed that messages by the instructor as a reply to students' statements, "other than initiation messages at the very beginning of the class," did not move the discussion further into a more interactive stage. In fact, instructor's postings during the discussion were referenced little by students, usually in a way of agreement with or confirmation of the instructor's statements. This might be due to the messages by the instructor included no or few statements that were initiative or linked to a specific statement by other(s).

Interaction Patterns

Message map analysis was conducted to determine interaction patterns among students over the duration of the discussions. Interaction patterns were found to vary from a discussion cluster to another discussion cluster on certain topics. Two types of interaction patterns were identified in the conferences: 1) messages explicitly or implicitly addressed the initiation message, and 2) messages explicitly or implicitly responded to the previous or above message (a stair-like form of interaction) (Figures 20 and 21 represent these message maps). However, interaction patterns in certain discussion clusters were not identical. Most of the discussions presented the combinations of these two types of interaction patterns identified above.

Figure 17 illustrates an example for the first type of interaction pattern. The majority of the messages posted in this discussion directly attempted to respond to the initiation message posted by the instructor. The professor provided the content and asked several questions for students to discuss. This was followed by a response from students. Of the total of messages posted in this discussion, nine messages directly addressed the professor's initiation message. Each student attempted to provide multiple independent responses to the initiation message, one after the other on a certain day.

This interaction also involved follow-up messages, which directly referred to other messages. For instance, student (#2) directly addressed the message posted by student (#1) through confirming and elaborating the statements by providing examples and questions. The professor also directly referred to the message posted by student (#1) by supporting the student's arguments with exemplary cases in the literature. The follow-up messages did not go further after a reply to a previous message. There was minimal interaction among participants.

In this discussion, only two messages (by the same student #2) with no link to any previous posting were followed-up by others. Without referring to any other previous posting, student (#2) provided examples in his two separate messages parallel to the on-going discussion topic from his own experience with his students. However, each of his messages was addressed once by others (instructor and student #1) with a short statement concerning how good the examples were that student (#2) brought to the class. Those messages were not elaborated or expanded upon by others.

Discussion #3

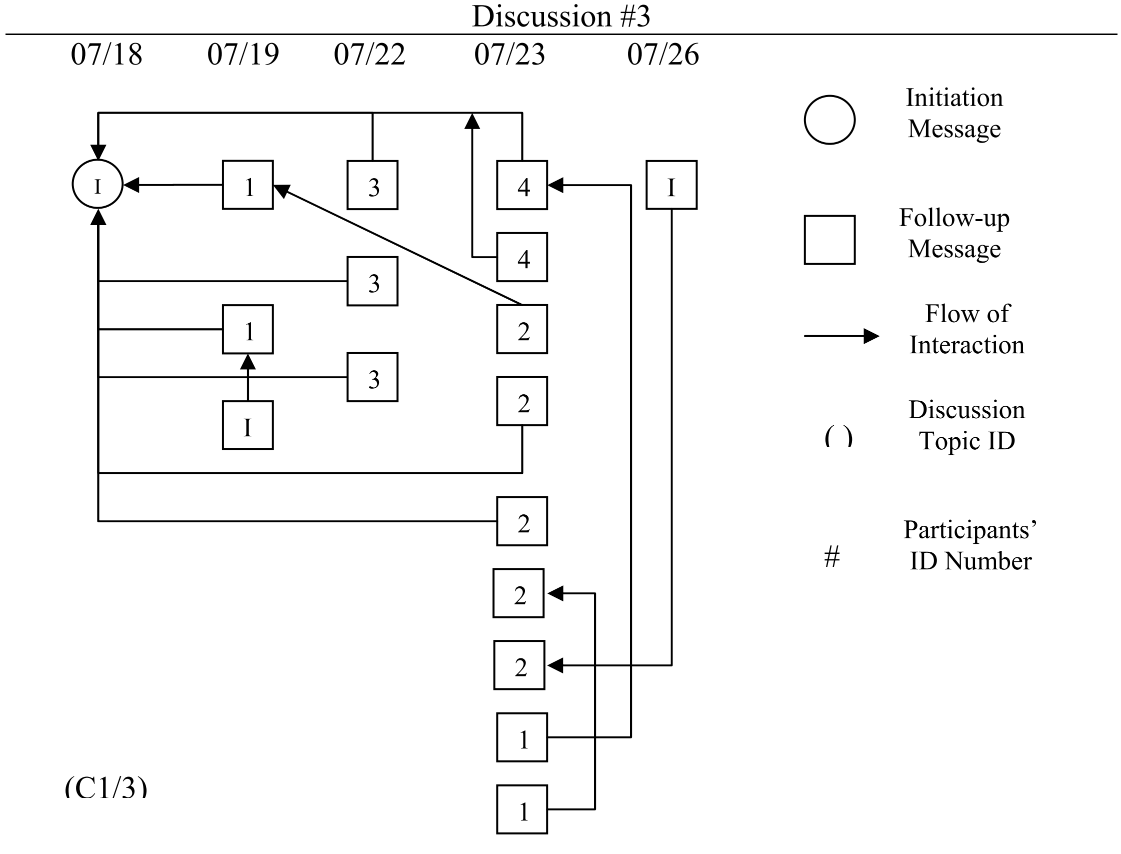


Figure 17. Interaction map in discussion #3

Figure 18 shows an example of the second type of interaction patterns, stair-like patterns, where participants tried to respond to the prior or above message; and Figure 19 shows a graphic representation of this type of interaction pattern. Typically, the interaction began with the instructor's prompt message and proceeded when students responded explicitly or implicitly to that message. Figure 18 indicates that the interaction went further between participants after responding to the instructor's message. Interaction evolved by two students' (student #1 and student #2) responses to the initiation message by the instructor. These students' responses gave rise to follow-up messages, including further examples, explanations, and elaborations. Five of the 12 messages were followed-up by participants to confirm the information presented, to propose new ideas, to correct concepts, and to support information with ideas or examples.

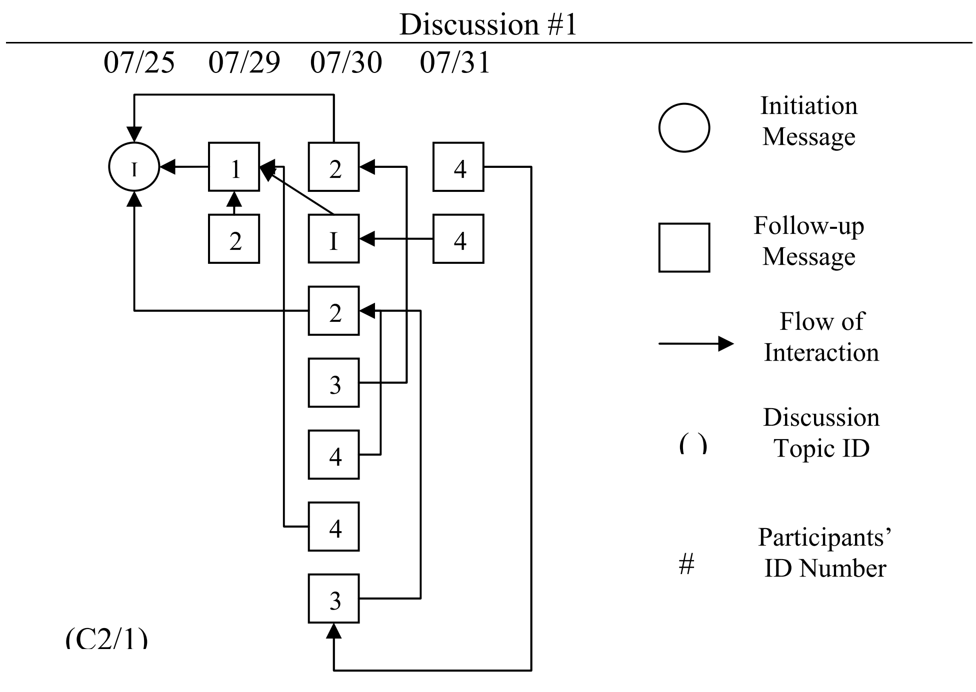


Figure 18. Interaction map in discussion #1

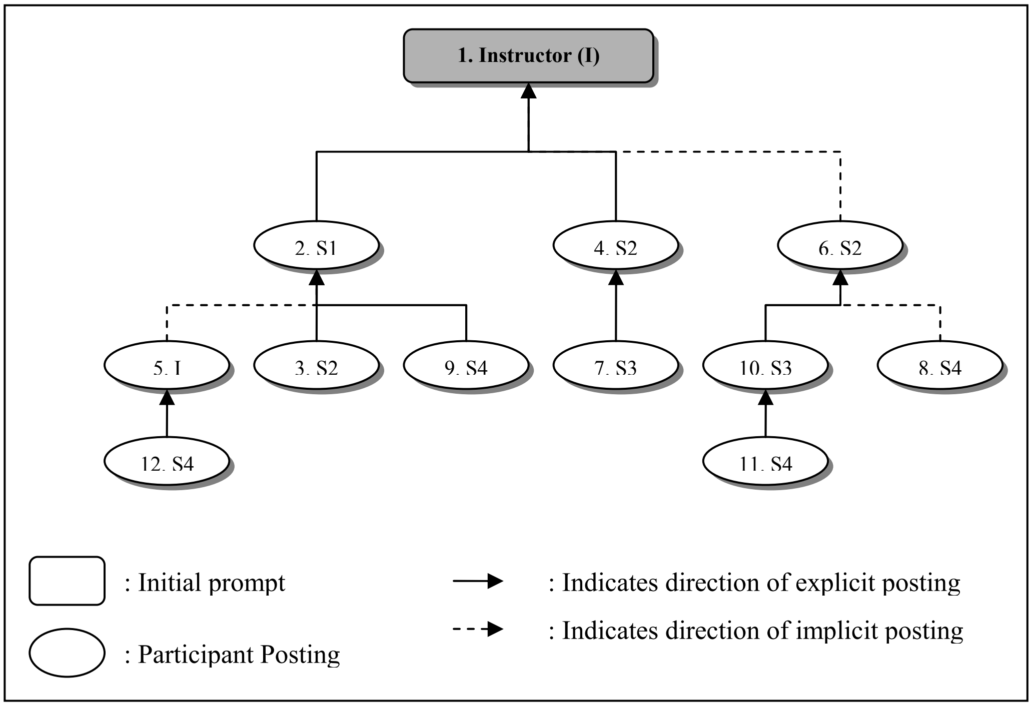


Figure 19. Stair-like interaction

Discussion

Interaction among students typically took place at fairly basic levels of interaction—confirming the information or statement posted by other(s), and/or initiating a new topic. For the most part, students either affirmed a topic, an idea, or an interpretation presented in an earlier message by a different contributor, initiated or proposed a new thread of discussion, or a new interpretation. Messages posted by students did not show evidence of controversial remarks or “disagreements with each other.” There was a lack of dissonance or disagreement among students that could have sparked more sustained, sophisticated, and interactive discussions.

This could be due to some students who contributed to the discussions just because of obtaining participation points. Therefore, their messages did not have any valuable or controversial content, but were merely surface level comments or statements, which did not lead to an interactive discussion among students. In addition, some students posted their replies or reactions to others during two or more occasions, one after another. Those students chose not to organize their thoughts in one message, but to organize and post them in different messages in a consecutive manner, and after having posted several messages, they tended not to continue to engage in the rest of the discussion. These type of interactions prevented students from participating in more complicated, interactive, and quality discussions.

In terms of interaction patterns among students, other than the two types of interactions described above (i.e., all messages addressed the initiation message and stair-like interactions), the analysis of data did not show complicated webs or threads of interactions where more than three participants interacted and replied to each other, or related their discussion to the previous or parallel discussions in a continuous exchange. It was found that students usually did not interact with each other in a multi-directional mode. Rather, they tended to interact in a more linear-like format. Few students contributed more than once in a discussion. Essentially, students limited their interaction to a one-time exchange and then stopped engaging in the discussion.

In addition, some students postponed their contribution until the last moment to participate by utilizing the time-independent and place-independent attributes of computer conferencing. While, according to CMC literature, the time and place-independence should have given students greater opportunity to participate and interact, these attributes seemed to have played a role for students in procrastinating their participation and limiting their interactions. In these cases, some students encountered that the discussion had progressed, changed or lost its tendency or direction so they could not comment, elaborate, or expand on the thoughts posted by others. Instead, they tried to contribute to discussions with independent messages directly addressed to the initiation message, which led to little interaction between peers.

The role of the instructor in online discussions may have had an effect on little interaction among students. The computer conferencing literature commonly states that online instructors should not become the center of attention or the authority that students look for approval; rather, they should facilitate discussions, promote and encourage student participation and interaction, in other words, “though the teacher needs to be present, the network enables the teacher to play a facilitative, observant, but background role” (Harasim et al., 1995, p. 174).

The instructor tried to follow this recommendation for online teaching. However, perhaps the instructor interpreted this recommendation too literally in that she stayed silent in some cases when her participation was necessary to foster class participation and interaction as well as redirect the discussion. The instructor’s interaction with students usually began with a prompt message by the instructor to initiate a discussion. The instructor interacted with students only for misconceptions, a need to answer a question, or to redirect the discussion. However, the instructor’s comments did not appear to promote further interaction among students. The instructor’s messages were rarely referenced and pursued by the students, and they seemed to have little influence on the flow and quality of interactions.

In conclusion, although all of the students’ messages were linked to at least one other message, interaction was limited mostly to one-time exchanges and occurred via confirming or elaborating on a statement and/or initiating or proposing a new topic.

Part III: Knowledge Construction

This section addresses the third objective of this study, to examine the knowledge construction in online discussions by identifying indicators of the knowledge construction process.

Findings

The analysis of data showed that the predominance of messages in both courses fell into the first two phases of the knowledge construction process (Phase I formed 85.8% of the total units analyzed in C1 and 76.3% in C2; Phase II formed 9% in C1 and 15% in C2). While only 12% of the units in C1 and 8.7% in C2 represented Phase III and Phase IV, in total, and there were no instances where Phase V statements emerged in the study. Table 19 outlines the phases and operational indicators of the knowledge construction process and the frequency of their occurrence in the study.

Students' messages showed considerable evidence they engaged in discussions to share and compare information (Phase I). Through sharing and comparing information, they also experienced cognitive conflicts and inconsistencies among various concepts (Phase II). However, students rarely negotiated the conflicts and the understanding or meaning of the new knowledge (Phase III), and tested or modified those negotiated meaning (Phase IV). Further, they never engaged in Phase V activities, such as reaching an agreement or showing application of new understanding, meaning, or knowledge.

Table 19. Knowledge Construction Categories & Indicators

Categories	Operational Indicators	C1 Total	C1 %	C2 Total	C2 %
Phase I. Sharing and comparing information	. A statement of observation or opinion	103	44.2	98	47.3
	. A statement of agreement from one or more other participants	7	3	9	4.3
	. Corroborating examples provided by one or more participants	34	14.6	41	19.8
	. Asking and/or answering questions to classify details of statements	35	15	6	2.9
	Definition, description, or identification of a problem	21	9	4	1.9
	Phase I	200	85.8	158	76.3
Phase II. Discovery or Exploration of dissonance or inconsistency among ideas, concepts, or statements	. Identifying and stating areas of disagreement	18	7.7	17	8.2
	. Asking and/or answering questions to clarify the source and extent of disagreement	3	1.3	9	4.3
	. 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	0	0	5	2.4
	Phase II	21	9	31	15
Phase III. Negotiation of meaning	. Negotiation or clarification of the meaning of terms	2	0.9	2	1
	. Negotiation of the relative weight to be assigned to types of argument	0	0	0	0
	. Identification of areas of agreement or overlap among conflicting concepts	0	0	1	0.5
	. Proposal and negotiation of new statements embodying compromise, co-construction	5	2.1	10	4.8

Table 19 (continued)

Phase III. Negotiation of meaning	. Proposal of integrating or accommodating metaphors or analogies	0	0	0	0
	Phase III	7	3	13	6.3
Phase IV. Testing and modifying proposed synthesis or meaning	. Testing the proposed synthesis against "received fact" as shared by the participants and/or their culture	0	0	0	0
	. Testing against existing cognitive schema	2	0.9	1	0.5
	. Testing against personal experience	0	0	3	1.4
	. Testing against formal data collected	0	0	0	0
	Testing against contradictory testimony in the literature	3	1.3	1	0.5
	Phase IV	5	2.1	5	2.4
Phase V. Agreement/application of newly-constructed meaning	. Summarization of agreement(s)	0	0	0	0
	. Applications of new knowledge	0	0	0	0
	. 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	0	0	0	0
	Phase V	0	0	0	0

Phase I: Sharing and comparing information

Among the categories of the knowledge construction process identified in Table 19, the majority of the contributions during computer conferencing occurred through Phase I statements (85.8% in C1 and 76.3% in C2). This indicates that students spent most of their time sharing or voicing their own opinions, comparing responses, and providing additional information to consolidate and support their views or interpretations.

Among the indicators of this phase, *stating a new observation or opinion* was the most frequent conceptual operation used by the students within C1 and C2 (44.2% for C1 and 47.3% for C2). For example, one student provided his own opinion on the issue of whether or not agricultural biotechnology played a vital role in the delivery of food assistance and reduction of hunger for generations to come: “I do believe that biotech has the potential to be the major factor in ending world hunger” (John, C1, Biotechnology & World Hunger). Students generally related the issues under discussion to their own experiences, and provided their observations, opinions or interpretations based mainly on their prior knowledge.

Corroborating examples provided by one or more participants was another conceptual indicator, commonly used by the students to share and compare information (14.6% for C1 and 19.8% for C2). For instance, one student gave a corroborating example about the places teachers utilize animals in educational settings: “Animals [could be] encased in acrylic or in jars of formalin. These specimens allow the students to see a 3-D animal that they wouldn't normally be able to view other than [with] a video tape or DVD. They get a better idea of size, color, and morphology than through photographs in the textbook.” (Mary, C2, Animals in Education)

Students also utilized *questions*, especially in C1 (15%), to classify and clarify details of statements and to interpret their own beliefs in Phase I. However, only 2.9% of the statements in C2 indicated that students asked or answered questions to classify or clarify details of information provided in the online discussions. Sometimes, they raised questions as a way to initiate a new discussion as well as a part of an ongoing discussion or in the middle of their messages to enrich and elaborate the issues addressed. Questions found in the messages, particularly information-request and reflective questions, indicated that students were involved in a process of clarification and self-reflection as they tried to present their ideas, comprehend the information given, and reach their interpretations. In the following example, a student asked peers several questions to clarify and understand the concepts in the assigned article by reflecting on some of the concern areas he had, in particular on the investment and return factors in scientific inquiry:

> Is this a good thing? Can this type of science possibly be conducted with the public interest in mind? Is Golden Rice being produced with the interest of those who need it at the forefront of the research or is the possibility of becoming rich at the forefront? If the motivations are financial, can there possibly be an objective answer to the ultimate safety of the product? (John, C1, Agricultural Biotechnology)

Other indicators, such as *a statement of agreement from one or more other participants*, and *definition, description, or identification of a problem,* together accounted for only 12% of the total indicators of the knowledge construction process in C1 and 6.2% in C2. For instance, a student agreed on what her classmate discussed, "I had [have] to agree with [John] on the first scenario there has to be a better way to deal with the removal of the limbs" (Tracy, C2, Animals in Research). Another student defined and identified a problem in a case study, related to the notion of biotech that has the potential to be the major factor in ending world hunger, "However, governments are SO corrupt that all one has to do is follow the dollars to see how even the greatest amount of assistance is being squandered." (John, C1, Biotechnology & World Hunger).

Many students' messages included a combination of operational indicators. In other words, students shared their own observations or ideas, responded and requested feedback from each other, provided examples, and identified problematic or conflicting areas with the information they had read. For instance, in the Ethics & Biotechnology course, students engaged in a discussion on whether or not genetically-engineered foods were safe to eat. Mary, a very active student, whose posts often prompted continued discussion through additional threads, provided background information, citing a resource and her personal opinion, observation and reflection [PhI/A], asked a question to clarify details of the statement [PhI/D] and provided additional opinions [PhI/A]. Later in her message, she asked a question to trigger the discussion in an attempt to obtain group consensus on the new information [PhI/D], and finally moved back to PhI/A by finalizing her message with her observation about the article and her own perspective about the education level of the general public.

> The Center for Food Safety writes:
>
> ‘A number of studies over the past decade have revealed that genetically engineered foods can pose serious risks to humans, domesticated animals, wildlife and the environment. Human health effects can include higher risks of toxicity, allergenicity, antibiotic resistance, immune-suppression and cancer.’ I would like to read about the studies mentioned.
>
> The articles that are "pro-biotech" have specific examples, instances, and research cited whereas the folks that are worried about GMO's are making blanket statements. Anyone else feel the same way?
>
> The American Medical Association gave a really comprehensive, well documented examination of the biotech topics.
>
> Still-What is the average "Joe" going to read? The AMA article was a high level read and the Center for Food Safety was simple and to the point. I wish the

general public was more educated... (Mary, C1, Safety) [Written verbatim from the on-line discussion]

John responded to Mary's opinion with a direct quotation [PhI/A], then made a statement of agreement with that quote [PhI/B], and provided his own opinion and an observation, supported by examples from his own experiences [PhI/A]. He later asked and answered a question to clarify his statements [PhI/D] with an example from his personal experiences [PhI/C] as well as his observations [PhI/A]. He ended by asking a question to elicit others' responses and views on the issues he raised. [PhI/D]

> '...I wish the general public was more educated...'
>
> Hey, I resemble that remark! Well, not really, but many of my friends and relatives do resemble that remark. I live in Appalachia (western NC in particular) and though I am sure that there are uneducated types everywhere, we have our fair share here.
>
> What is my 40 year old cousin who has a 10th grade education and works in a furniture factory going to think about biotechnology?......NOTHING! He raises most of his veggies in his own garden and buys beef and pork by the 1/2 animal from the farmer just across at the next small family farm. He could give a rats behind about this entire discussion as it is so removed from him that we are all on another planet.
>
> What do we do about those who are not only uninformed, but could care less? (John, C1, Safety) [Written verbatim from the on-line discussion]

As can be seen from these examples, students typically used a combination of Phase I operational indicators. Of particular interest is the highly positive nature of the reaction from students coded as responding to each other's triggering questions. This positive reaction or feedback was often followed by further confirmation or elaboration, a statement of new observations or opinions supported with personal examples, and/or identification of new problems.

In the next example, Diane referred back to and confirmed the statements made by Mary and John. [PhI/B] He attempted to define the problem mentioned by both Mary and John earlier from a different perspective [PhI/E], he then provided a citation and his personal observation and opinion about the class article [PhI/A]. Next, he defined and identified a problem with the information in the article [PhI/E], and mentioned another article which was short and easy to read in contrast with the previous one [PhI/A]. Finally, he asked a question [PhI/D] and provided specific examples from his teaching experiences to expand and elaborate the discussion [PhI/C].

> I agree with [Mary] and [John] - trying to educate the masses is almost an impossible task. Some of the problems I see are that many people [are] apathetic to some many areas and are definitely afraid of change. I saw this saying once ‘An intelligent man is willing to change his mind but a fool never will.’
>
> I also thought the AMA article was to[o] deep for the general public - I thought it was a very good and informative article (and a little long). AMA took a positive look at GM foods but the general public probably wouldn't read it. On the other hand the article by the Center for Food Safety- which was against GM foods was short and easy reading– the public could handle this one - so what happens you have two opposing views - one the public won't or couldn't read and one they could - which view will they take?????

> I have noticed this in my classroom discussion about GM foods - that the students' grandparents probably would not buy a food if they knew it was GM, ...The students themselves said it really didn't matter as long as it tasted good and the price was right. The students (in Iowa) have been exposed to DNA and DNA technology in the classes - especially with the labs like, extracting their own DNA and checking their genotype for the Alu gene, DNA fingerprinting, and DNA transformations. Also these students being from the Midwest have been exposed to the DNA applications in crop and livestock operations. (Diane, C1, Safety) [Written verbatim from the on-line discussion]

These examples illustrate how students spent a majority of their conceptual learning in the first phase of the knowledge construction process. Interactions like these indicated that the basis for the interpretations students shared included observations and interpretations grounded in their prior knowledge and personal experiences.

Phase II: Exploration of dissonance or inconsistency

The theoretical framework for this study suggested that sharing and comparing information would cause students to discover and explore inconsistencies between ideas or statements by others. However, only 9% of knowledge construction indicators represented *exploration of dissonance or inconsistency among ideas, concepts, or statements* in C1 and 15% in C2 (see Table 19). Although, students shared and compared a considerable amount of information, observations, and/or opinions, they rarely experienced cognitive disequilibrium or dissonance among ideas, concepts, or statements (Phase II).

Among Phase II indicators, *identifying and stating areas of disagreement* (PhII/A, see Table 19) with the readings was the most frequent indicator utilized by the students (7.7% for

C1 and 8.2% for C2). For instance, Diane identified an area of disagreement or conflict within the article she read. He explored a conflicting area with the information in a class article related to some researchers developing a product, which would only let one type of pollen germinate.

> …what if he has a patent on that gene-protein and the pharm researchers would like to incorporate in their product and he would have it at such a high price the pharm [r]esearch wouldn't by it. Now we are back to we have all this technology and new information/ability but can't use it because of a patent on a certain gene (Diane, C1, Agricultural Biotechnology) [Written verbatim from the on-line discussion]

It was interesting that participants never disagreed with each other, only with the positions presented in the readings.

The second most frequent operational indicator of Phase II among students was *asking and/or answering questions to clarify the source and extent of disagreement* (1.3% for C1 and 4.3% for C2). After identifying or exploring dissonances or inconsistencies among statements or concepts, students attempted to ask and/or answer questions to clarify them. In this example the student identified an area of disagreement with the procedures researchers used and then asked a question to clarify. “I don't approve of the people given the hepatitis strain. And how can it be justified that the people signed a release when they didn't do what they said that they were going to do[?]” (Susan, C2, Animals in Research)

Students also exhibited another operational indicator of Phase II, *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* in C2 (2.4%). However, there were no instances found in C1 related to this type of operational indicator of the knowledge construction process. In the next example, Diane responded to the example above to restate his dissonance through a reference to his own experience to illustrate his viewpoint. “Speaking as a stepmother to a mentally retarded child I can't imagine Tonja being put through this inhumane treatment.” (Diane, C2, Animals in Research)

The next example demonstrates that knowledge construction phases tended to be iterative and nonlinear. This finding is consistent with previous research (see Gunawardena et al., 1997). In one activity, students were asked to write a letter which included their justifications to a question asked by the instructor about a case study called Golden Rice. In this real-life example of how biotechnology can be used to help developing nations, Diane’s response exemplified the first two phases of the knowledge construction process. Diane first provided his own observation and ideas (coded as PhI/A). He then identified problems (PhI/E) and experienced cognitive dissonance and inconsistency between the information given and his own existing cognitive framework (PhII/A). Finally, he tried to ask and answer questions to clarify the source of dissonance (PhII/B).

> In the letter I would tell them to continue the research on golden rice, especially trying to get a greater beta-carotene amount in the rice. In the articles opposing this mentioned that they would have to eat 20 pounds of golden rice each day - this was from Greenpeace whom I think are very conservative in their thinking and their way - I don't trust them. It appears that Potrykus and Beyer don't deny the small amounts of beta-carotene their rice contains, which would supply 8% of the vitamin needed in a normal diet.

> There are not many processed foods (boxes of cereal, milk, etc) on the market which contains 100% of one or all of the vitamin requirements. So I would like them to continue their work trying to get a greater percentage of beta-carotene being produced. I would also want these seeds to be financially possible to the target populations.
>
> Additional thought: I'm almost 100% in favor of GM's but the problem I have is the ability of these companies to own a patent of a specific gene. I think this is totally wrong and with various companies owning these genes it will slow down research tremendously and maybe even prevent some research from taking place. The cost of the gene and the possibility of a law suit turns much of the research away. If Monsanto went after a small farmer whose field was accidentally contaminated by GM rape seed pollen and won the case - what would it be like if a company or corporation doing research had a contamination problem - that research would probably shut down. (Diane, C1, Agricultural Biotechnology) [Written verbatim from the on-line discussion]

John experienced considerable cognitive dissonance when trying to respond to the instructor's question. He tried to advance the discussion by supporting his observations with a reference to an article assigned to the class, and identified and stated areas of disagreements with content information.

> The article titled "Socioeconomic Aspects of Biotechnology" outlined some of the other areas of concern upon which the question of biotech touches. Some of my concerns have dealt with economics and motivation. I am a capitalist, for sure... however, when public saftey [*sic*] is concerned, I am concerned that having the dollar

> as a primary motivator of research and implementation of GM plants and animals is dangerous. (John, C1, Agricultural Biotechnology) [Written verbatim from the on-line discussion]

Students in the conference who held conflicting viewpoints on an issue did not debate their perspectives with their peers. They experienced cognitive dissonance only through concepts, examples, or case studies presented in the course content. Usually, students demonstrated conflicting or alternative views in independent messages not well integrated into the group discussions. Although these alternative or opposite viewpoints with the concepts in the course content provided a different framework for further analysis and discussion of issues underway, no indication was found regarding students arguing these conflicting viewpoints within the group.

For instance, a student identified an area of disagreement or conflicting viewpoint on some issues in an article assigned to the class. She attempted to clarify the source and extent of inconsistent issues by posing questions for others. However, no response, feedback, or alternative viewpoint was provided to her message by other students; thus, this message contained no follow-ups, and no negotiation of meaning or higher phases of the knowledge construction process took place as a result of this.

> I wonder if someone can enlighten me as to the comparison of the biotechnology issues of making plants resistant to lets say the weed killer that the farmers spray on their crops, as talked about in one of the articles, and the reproductions down the road of them being resistant to that and then having to make them resistant to something else because the plants develop a resistance too. Are we eventually going to have to have the plants resistant to all of the weed killers too.

> Where does this stop? I can see a snowball effect. Am I just reading this wrong or are we going to have to end up with exact growing plants?
>
> Also what about the monarch butterflies. It sounds like they could be harmed by the Bt [biotechnology] plants. Is this article just one way and I am not seeing it all. It sounds like the seed is great but it scares [me] the implications of it on other things. I am probably just having a crazy moment but is anyone else out there seeing my point?
>
> It also sounds like we use products from biotechnology all the time and just don't know it. Do the people who are totally against this know that? If so then how will they eat etc. Are these the people who eat only organic grown crops or am I way off base? (Susan, C1, Agricultural Biotechnology) [Written verbatim from the on-line discussion]

Based on the theoretical framework of this study, Phase II units are imperative. They reflect cognitive conflicts that are the impetus for and critical to a new understanding and knowledge construction. Although students actively shared and compared information, they experienced little cognitive conflict. Lack of debate among students on the controversial issues could be an important factor in the minimal occurrence of Phase II interactions (e.g., cognitive conflict) in this study.

Phase III: Negotiation of meaning

Since there were few instances of Phase II interactions, and the third phase of the knowledge construction process focuses on the *resolution* of cognitive conflicts and negotiation of meaning, it was not surprising that very few indicators were found in this phase (3% in C1 and 6.3% in C2). *Proposal and negotiation of new statements embodying* *compromise, co-construction* represented most of the Phase III knowledge construction indicators (2.1% for C1 and 4.8% for C2). In commenting on genetically-modified research within the case study called Golden Rice, Diane proposed the notion of "pharming" as a solution to reduce the cost of medicines and vaccines:

> …[pharming] could be a way of lowering the product cost by eliminating the large sterile facilities. The purifying and processing is easier and cheaper….pharming would create more and different meds at a lower price - especially if we could get rid of the patenting of genes. (Diane, C1, Agricultural Biotechnology)

Among the indicators of Phase III, students rarely *negotiated or clarified the meaning of terms* (0.9% in C1 and 1% in C2), or *identified areas of agreement or overlap among conflicting concepts* (no instances found in C1 and .5% in C2). John, in this example, attempted to negotiate and clarify the notion of experiments on animals and identify an area of overlap: "these tactics [experiments on animals] would fall very close to being illegal as I understand the federal regulations. However, if these practices do find themselves to be legal, a serious moral question is raised by the lack of concern for the animal being used." (John, C2, Animals in Research).

Other indicators of Phase III such as *negotiation of the relative weight to be assigned to types of argument* [PhIII/B] and *proposal of integrating or accommodating metaphors or analogies* [PhIII/E] were not found in students' postings (see Table 19).

Negotiation of different meaning, understanding, and conflicting viewpoints is a fundamental aspect of constructivist learning environments, learning arises as students attempt to see an issue from different vantage perspectives that encourage them to modify their cognitive framework (Bednar et al., 1992). Furthermore, as students negotiate or elaborate on others' comments, a more complex understanding can evolve. In the computer conferences investigated in this study, the rare occurrences of knowledge construction appeared to result as students negotiated issues and exchanged ideas with their peers during the conference. Where students were observed to engage in negotiation of different meanings or understanding and in elaborating upon other students' postings in a collaborative manner, the co-construction of ideas resulted. However, as mentioned, since students did not engage in discussing their conflicting viewpoints to any prolonged extent in Phase II, they demonstrated few instances where they negotiated alternative perspectives, information, meaning, or understanding.

Phase IV: Testing and modifying proposed synthesis or meaning

Only 2.1% of the total units in C1 and 2.4% of those in C2 reflected Phase IV (testing and modifying the proposed synthesis or meaning) knowledge construction indicators. Among the indicators of Phase IV, *testing against existing cognitive schema* and *testing against contradictory testimony in the literature* were the most frequent indicators that occurred during online discussions. The following message exemplified these two indicators. This quote followed an argument on the vital role of agricultural biotechnology, especially, on the delivery of food assistance and reduction of hunger for generations to come, and not relying upon other countries to survive. The message began at Phase IV, testing the information against cognitive schema [PhIV/B], then tested the issue of the safety of foods against contradictory testimony in the literature [PhIV/E], and concluded with statements testing the information against cognitive schema [PhIV/B]:

> I started wondering about how other countries "feel" about biotech crops. Just because we can make these foods safe to a great extent, how can we expect other

> countries to accept these products? …What if other countries believe that because the hand of nature has been forced or tampered with, perhaps that alone is grounds for not wanting the crops. So maybe we are working and growing wonderful products for a world that doesn't want them. Hummm. (Mary, C1, Biotechnology & World Hunger)

Testing against personal experience was another Phase IV indicator that occurred in students' messages. There were no instances found in C1, while only 1.4% of the total units in C2 reflected this indicator. For instance, the instructor asked students to provide their responses on different views about animal experimentation such as 'moral views' or 'on balance justification view,' and whether they are against or for animal experimentation in terms of the medical benefits it provides. After Diane provided his response, he asked reflective questions to test the proposed synthesis against his personal experience: "Could I ever do it? No way. Could I look into those sweet innocent eyes and inject them with a deadly virus? Absolutely not." (Diane, C2, Animals in Research)

In Phase IV, no evidence was found in conference transcripts that students *tested the proposed synthesis against "received fact" as shared by the participants and/or the culture* [PhIV/A] and *against formal data collected* [PhIV/D] (see Table 19).

Phase IV of the knowledge construction process reflects students' cognitive restructuring; in other words, modification of existing cognitive framework. Based on constructivist theory, the notion of cognitive restructuring or re-organization of thinking is significant to assimilate and accommodate knowledge that lead to successful application of that newly-constructed knowledge. In this study, however, for the most part cognitive restructuring or cognitive change was not directly observed in the computer conference.

Students rarely engaged in deep and critical thinking as they engaged in constructivist activity and actively restructured their cognitive frameworks (Jonassen, 1991).

Phase V: Agreement/application of newly-constructed meaning

According to the theoretical framework of this study, students would apply Phase V operations, developing new meaning or knowledge through *summarization of agreement(s) or metacognitive statements illustrating students' understanding that their knowledge has changed* as a result of testing and modifying of meaning (Phase IV). However, no evidence was found in the data related to any operational indicators of Phase V. Students did not engage in applying new knowledge, such as through metacognitive thinking, as a result of their participation and interaction with their peers in the discussions. This was likely due to the little occurrence of Phase III and Phase IV indicators, where students negotiated different meanings, tested those meanings, and changed their understanding accordingly.

The occurrence of multiple phases within a message

With the exception of Phase V indicators, analysis showed that students' messages reflected varying degrees of the first four phases of the knowledge construction. Students' messages reflected not only a combination of indicators within a specific knowledge construction category, but also instances from different categories. The following post is an example of multiple phases and several operations within one message. The author tried to highlight the "Experiment Discomfort" issue in the case study, as he attempted to move the discussion from Phase I to Phase III. First, he provided his observation and opinion about the information in the case study [PHI/A]. Second, he identified specific areas of disagreement with the information [PhII/A]. Third, he negotiated a new meaning by making a proposal of a new statement embodying compromise [PhIII/D]. Finally, he returned to Phase II, where he continued to state and elaborate areas of inconsistent ideas about the methods used for animal experimentation [PhII/A]. This example illustrates how students move back and forth between identifying areas of conflict and negotiating meaning.

> In the case study on "Experiment Discomfort" I found the decisions made by the researchers to be disturbing. First, the choice of carbon dioxide as the anesthetic to be inhumane. The choices of anesthetic available today would seem to make the use of carbon dioxide unnecessary. The suffering brought about by the withholding of oxygen leading to the struggle and panic of the animal is cruel.
>
> Additionally, the removal of the legs seemed to me to be over the top. I am no scientist, but their explanation as to why the legs would be removed was weak. If a more appropriate and controlled anesthetic were used, then the animal might stay down longer and make the removal of the legs unnecessary.
>
> Lastly, with the animal conscious and the experimentation continuing without any anesthetic and the animal in a "shock" state over the removal of the legs, the cruelty seems to be amplified. (John, C2, Animals in Research)

Discussion

Consequently, the analysis of the computer conferencing transcripts showed little occurrence of the higher phases of the knowledge construction process (e.g., Phases III and IV, and no Phase V). The fact that students' contributions indicated little evidence for the higher phases could be due to a number of reasons. First, there was a general lack of debate among participants. In general, students tended not to disagree with each other. They usually agreed and engaged in the processes of sharing and comparing information and/or their personal experiences. Consequently, students' existing knowledge was rarely challenged.

Therefore, many discussions appeared to have been left undeveloped, with no debate of conflicting viewpoints. Students were not lead to explore alternative ideas and generate a new perspective through the discussions, and messages showed little evidence of the higher phases of the knowledge construction process.

Alternatively, perhaps students lacked experience or skills required to engage in a prolonged critical debate, and pedagogical interventions were not sufficient to prompt development of these skills. As previously mentioned, students were inexperienced in online learning. They were accustomed to conventional ways of teaching and learning, where the teacher leads discussion and there are few opportunities for discussion and debate among students. Thus, students may have lacked the experience and skills necessary to enter in a critical examination of the topic being discussed in the online environment.

Summary of the Findings

Participation among students in the computer conferencing was neither high nor evenly distributed. Some students contributed to online discussions more actively than others, whereas some tended to participate in discussions just to fulfill the class participation requirement.

Contrary to participation, interaction among students in the computer conferencing could be considered high, since all student messages were linked to each other, either explicitly or implicitly. However, interaction among students did not show continuous exchanges. Most messages were followed up only once, and did not generate or advance discussions. Conference postings usually showed students' own trends of thoughts or interpretations, even if those included questioning or responding statements. Interaction among students reflected either vertical interaction patterns (i.e., messages explicitly or implicitly addressed the initiation message) or horizontal interaction patterns (i.e., messages explicitly or implicitly responded to the previous or above message, a stair-like form of interaction) or a combination of these, and lacked more complex interaction patterns (e.g., star-like interaction), which include more than three participants interacting and replying to each other, or relating their discussions to previous or parallel discussions in a continuous exchange.

In many cases, students did not reach their interpretations, based on the examination of information or different perspectives raised in the discussions, but created their own interpretations and beliefs, based on the issues they pointed out in their previous messages. Students did not always consider others' statements as a valuable source of knowledge; hence, they exhibited the act of speaking alone, soliloquy, in their messages. For the most part, students limited their interaction to one-time exchanges and stopped engaging in the discussion.

Interaction among students usually took place through confirming or elaborating the information/statement posted by other(s) as well as initiating or posing a new topic or idea. The analysis of the messages' contents revealed no evidence that students disagreed with each other. Students tended not to disagree with each other or consider alternative viewpoints, which prevented them from discussing issues in a more sophisticated and in-depth way.

Major indicators that contributed to the process of knowledge construction were sharing and comparing of information (Phase I). Students frequently identified areas for discussion and posted their observation or opinion about these areas, and elaborated on others' ideas by using examples, asking or answering questions, and defining problematic issues. This sharing/comparing of information process included mainly the use of personal observations or opinions, as well as examples drawn from students' experiences or knowledge. This category of knowledge construction typified mainly a process, whereby students interpreted their own beliefs and reflected on them. Questions were also used by students as a way of clarifying, and interpreting ideas and assumptions in Phase I.

Although sharing and/or comparing information appeared to help the process of knowledge construction, the latter phases took place in the discussions to a much lesser degree. Phase II occurred occasionally in the discussions when students experienced cognitive conflicts. However, discussions reflected this category were rare and carried out by few students. As stated in the interaction section, students did not make any controversial remarks or state conflicting viewpoints based on other participants' statements. Thus, they did not experience cognitive conflict within the group. The analysis of the messages showed similar findings in Phase II to those in the interaction section, such that students did not explore cognitive dissonance within the conference, although they identified conflicts and/or inconsistencies among concepts presented in the course content.

Although the first phase of the knowledge construction process is an important stage, conceptual change and cognitive restructuring take place in the latter phases. Consequently, the overall findings showed that the higher phases of knowledge construction rarely occurred in these discussions.

CHAPTER V: CONCLUSION

Constructivist theories about knowledge construction emphasize that knowledge construction is more powerful and meaningful when it is actively built up by students through engaging equilibrated exchanges and experiencing cognitive disequilibrium. In this sense, knowledge construction is viewed as "a self-regulatory process of struggling with the conflict between existing personal models of the world and discrepant new insights, constructing new representations and models of reality as a human meaning-making venture with culturally developed tools and symbols, and further negotiating such meaning through cooperative social activity, discourse, and debate" (Fosnot, 1996, p. ix). Knowledge construction is thought to be effective when we are able to participate and interact in a community of learners that entails opportunities and incentives to collect, record, and analyze data; examine and evaluate learning processes; reflect on previous understandings; and construct knowledge applicable to new and different situations (Crotty, 1994).

Computer-mediated communication, and more specifically computer conferencing system, has been recognized as an ideal tool to create this type of learning environment featuring active, participative, and reflective learning. The attributes of computer conferencing create a shared space, a mutually supportive collaborative environment in which peer-to-peer interaction is encouraged with the opportunity to reflect on alternative perspectives, propositions, and insights. Many researchers claim that computer conferencing represents the potential to facilitate active participation, interaction, and knowledge construction (Garrison, 1997; Harasim, 1987; Wiesenberg & Hutton, 1996).

This study was conducted to examine whether knowledge construction was promoted through computer conferencing. The results demonstrated that in an environment where students had opportunities to share ideas through asynchronous written communication, the majority of their interactions reflected the first phase of Gunawardena's (1997) Interaction Analysis Model framework. These findings are consistent with results from other research (see Gunawardena, 1977; Zhu, 1996). For instance, in a study of critical thinking during group learning in computer conference seminars, 63% of the interaction included sharing ideas, information, and justification (Newman et al., 995). Another study assessed the nature and quality of the critical-thinking process as reflected in a computer conference transcript. The findings showed that the majority of students' postings indicated that students brainstormed, shared and compared their insights, and contributed relevant information (Garrison et al., 2001).

Factors Affecting the Knowledge Construction Process

Three factors emerged from this study that appeared to have an effect on students' knowledge construction. They were: 1) students' experience in online learning environments, 2) the instructor's role in the online discussions, and 3) lack of debate among students.

Students' Experience in Online Learning

The instructor in this study tried to follow recommendations for online teaching and learning environments by giving up center stage and observing students' interactions from a distance, only entering into the discussion when necessary (Berge, 1995). However, students in this study were unfamiliar with that type of learning environment. Before taking the Bioethics courses, none of the students had any experience in an online teaching and learning environment. Students were accustomed to more didactic approaches to teaching (Sternberg, 1987), where the instructor lectures, the students listen and take notes, and there is limited interaction among course participants during the class. These students had little experience in discussing controversial ethical issues in any format—much less in an asynchronous text-based online environment.

Computer conferencing requires students to actively participate and interact with others by making written contributions to discussions. These activities generally require high demands from students, such as self-directed cognitive engagement in the discussions and time-management [when compared to traditional classrooms]. Students are responsible for determining when, where, and how they will participate in class. For those learners in need of more structure and support (e.g., frequent and immediate feedback with respect to their learning progress), the increase in responsibility, or learner autonomy, can actually become an obstacle to learning (Berge & Collins, 1995; Heller & Kearsley, 1996; Kelly, Futoran, & McGrath, 1990, Ruberg et al., 1996).

In addition, computer conferencing can create a potential for confusion due to multiple and simultaneous discussion threads, and the often extensive time gaps between posting and receiving a response in computer conferencing can create difficulties for students. Some students experience anxiety when there is no immediate reaction to their posts, causing them to think that other participants are either not there or are ignoring them (Harasim, 1990). Students can easily lose the focus or momentum of discussion (Tiene, 2000), as well as their opportunity to make contribution because of the presence of time lag (Harasim, 1990).

In order to engage in reflective, in-depth discussions, students need to be comfortable with and effectively use the attributes of asynchronous computer conferencing such as many-to-many communication, and time and place-independent communication. Students in this study appeared to be lacking many of the experiences and skills required for effective learning and knowledge construction in an online environment. Furthermore, research might shed some light on the impact of students' experiences with online learning environments on their construction of knowledge in computer conferencing systems.

The Instructor's Role in the Online Discussions

Teaching style is another issue that can have an impact on students' knowledge construction process. According to some researchers, the best approach for facilitating knowledge construction involves taking a more active role in introducing discussions, raising issues, focusing the discussions, synthesizing issues raised by the students, and connecting those issues to relevant literature (Berge, 1995; Harasim, 1987). As discussed earlier, the instructor in this study followed some of these recommendations—initiating discussions by posing questions, providing feedback, and sharing information.

However, these approaches appeared to have little influence on student participation and interaction. The instructor's interactions with students did not encourage them to create conflicting viewpoints and, thus, foster knowledge construction. And when this became obvious, the instructor did not adjust her approach in order to stimulate greater participation, interaction, or cognitive conflict among students.

Perhaps continual and directive involvement by the instructor would help those students who are unfamiliar with self-directed learning in an online class to participate in ways that would foster more knowledge construction opportunities. This would allow students to experience the teacher's presence for those who need more guidance and structure. However, it is critical to balance the amount of the instructor's presence in the computer conferencing to facilitate the quality and the flow of discussions without becoming a center point or dominator of the discussion. Some studies showed that interaction among students tended to decrease when the instructor took a more active role (Ellis & McCreary, 1985), while others reported findings consistent with this study. Inconsistency of instructor participation and interaction with students inhibited in-depth discussions of ideas or issues.

In addition, the instructor in this study created a discussion rubric (see Table 10), which provided guidelines for effective interactive messages. However, the instructor did not introduce it to students. Perhaps this may be another factor for the little presence of higher-level knowledge construction among students, since it could have assisted inexperienced online students in their interaction with peers and the instructor, as well as in organizing their thoughts based on this rubric. The effects of teaching style, or instructional strategy, deserve more attention. Further research might examine particular styles of the instructor's participation and interaction with students in online discussions; for example, how a more dynamic participation on the part of the instructor would affect student interactive engagement in discussing controversial issues, or how a course design that encourages more interaction and collaboration among students could make the knowledge construction process more effective and online learning more meaningful.

Lack of Debate

Lack of debate among students appeared to be another factor that hindered the development of knowledge in this study. The bioethics courses introduced both very abstract ideas about ethics and specific ethical issues. These courses included case studies as structured activities to focus attention on the ethical aspects of concrete issues. It was one of the course's instructional strategies that using a case study format allowed for more detailed discussion of a particular issue, because it provides a forum for investigating a particular issue in more depth.

However, the analysis of the content in students' messages revealed that students rarely engaged in detailed discussion of a particular issue. The common discussion type observed among students was sharing opinion, confirming information, and providing personal experiences. Messages posted by students included little valuable and critical information, but mostly surface level comments or statements to obtain participation points. Usually, the students tended to agree with each other or tended not to challenge each other's views, even if they had conflicting viewpoints. These students, who were not familiar with online learning, were not accustomed to debating controversial issues through text-based communication. Perhaps, if those students who held conflicting issues had discussed their views through questioning and exploring alternative viewpoints, higher levels of participation and interaction might have been observed; hence, more evidence of the higher phases of the knowledge construction process. A future study might examine the effects of experiencing cognitive conflict on participation, interaction, and knowledge construction in online discussions.

Recommendations and Implications for Practice

Based on the insights above, the following recommendations were made to help design successful teaching and learning activities in computer conferencing systems.

Create introductory activities for the online discussions. Due to the fact that asynchronous online discussions are a new activity for most students, learning tasks can quickly overwhelm those who lack experience in online learning. Before students can independently use online discussion tools to construct knowledge, they need to be familiar with using the online environment. They can learn basic skills, such as how to reply to messages, create new discussion threads, and so on through introductory discussions as a training activity, so that students can have a clear sense of online discussions.

Establish and provide clear guidelines, structure, and expectations. It is helpful to set up guidelines for students that describe the nature of the discussion expected and the criteria used to evaluate participation in the discussions. Students need clear structure and guidance, as well as explicit expectations, because even experienced students can become confused and lost online. To make full use of online discussions for critical and reflective thinking as well as knowledge construction, the instructor should establish clear expectations for participation and interaction at the beginning of the course. The instructor should also be clear about grading criteria for assignments, specific times and dates when postings are due (especially deadlines for initial posts and required responses to others), and the length and style of postings. Clear guidelines and samples should also be prepared for the kinds of content that are or are not appropriate, and for ways to initiate a discussion, respond to a message, reflect on an idea, and conclude a statement.

Encourage students to share controversies or conflicts. Students, in many cases, are too nice to each other during Web-based interactions, rarely disagreeing with each other. This may be because they have minimal face-to-face interactions or prior shared experience. However, the most active and effective discussions include conflicting viewpoints or alternative perspectives, which are purpose and task-oriented. The instructor should put students into cognitively challenging situations and present activities that require considering opposing views and encourage students to debate or discuss their controversial remarks with others.

Students' comments also often lack justifications of their alternative views, which may lead to another perspective by another student so that discussion would become more cohesive and rich. Students may not realize that they are supposed to justify their views or reasoning. In this case, the instructor should encourage them to back up their claims and link their concepts on a basis from textbook or other course materials.

Facilitate discussions. This study suggests that the instructor's role, in terms of her participation in discussions and facilitation of the discussions, is crucial for students to construct new understanding of the abstract issues. Uneven instructor participation in the discussions was evident. Teacher presence plays a critical role in identifying key issues remaining to be addressed and misconceptions posed by students. The instructor can facilitate discussion in several ways. Among them are suggesting paths for further development of ideas; posing well-designed, direct questions to motivate students and keep the discussion active; and giving reflective and critical feedback to students' statements. Similar to face-to-face discussions, online discussions require periodic and timely feedback. Therefore, online students should be given feedback about their statements periodically, which can help promote prolonged and active engagement by students.

Require students to self-reflect on and self-code responses. Instructors should also consider asking students to critically evaluate their postings and self-code their discussion roles and the types of their postings, based on learning objectives set by the instructor (Duffy, Dueber, & Hawley, 1998). This would encourage students to keep track of their own learning processes and raise students' awareness, for example, of the five phases of the knowledge construction process. A student can have the role of sharing or comparing information or disagreeing with others so that he or she can code his or her posting, depending on the role and type of message. Through this metacognitive strategy, students remain in charge of their own cognitive and interactive behavior in the discussions.

Computer conferencing by itself does not guarantee increased participation, interaction, and cognitive conflict among students. The findings of this study revealed that it is not easy to design and moderate online discussions to be effective in knowledge construction. Although the attributes of computer conferencing may provide the potential to increase students' participation, create interactive educational experience, and establish an environment where students can experience higher-order thinking skills, making this happen requires more than the technology. The instructor must make it happen by providing opportunities for students to participate actively in the learning progress, engage in depth-discussions with their peers, challenge each others' viewpoints, explore cognitive dissonances, and create better understanding, meaning, or knowledge. The instructor's role in designing computer conferencing as a learning environment is crucial for fostering knowledge construction and should be given serious consideration by online education.

APPENDIX A: COURSE SYYLLABUS (ETHICS & BIOTECHNOLOGY)

Course Information

Course title:	Ethics and Biotechnology
Course number:	PHIL 546X
Course discipline:	Philosophy
Course description:	Modern biotechnology is as controversial as it is promising. Teaching the associated ethical issues can help engage students to learn the relevant science concepts and to learn the skills necessary to contribute to ongoing social dialogue about science and society. Topics include an overview of ethical controversies about biotechnology and specific ethical issues in plant, animal, and human biotechnology.
Course date:	Monday, July 11, 2005 through Friday, July 29, 2005
Location:	Online.

Textbooks

Required reading:	*All material online.*

Week 1

Lesson:	Overview: Biotechnology and Ethics
Date:	Monday, July 11, 2005
Objectives or Goals:	This unit will: provide background resources on biotechnology; introduce some prominent ethical arguments about biotechnology; provide an overview of the entire course.
Assignments:	Participation in discussion. First draft of position paper due by midnight on Sunday 7/17.

Week 2

Lesson:	Agricultural Biotechnology
Date:	Monday, July 18, 2005
Objectives or Goals:	After this unit, you will better understand: various applications of biotechnology in agriculture; the various controversies about agricultural biotechnology; distinct ethical arguments about agricultural biotechnology; your own views about one specific product of biotechnology, golden rice.
Topics:	Ethical arguments about: food safety; biotechnology and world hunger; labeling foods produced using biotechnology; agricultural biotechnology and the environment; using crops to produce pharmaceutical or industrial compounds; biotechnology and animals.
Assignments:	Participate in discussion. 2nd draft of position paper due by midnight on Sunday 7/24.

Week 3

Lesson:	Medical Biotechnology

Date:	Monday, July 25, 2005
Objectives or Goals:	After completing this lesson, you will understand: distinct medical applications of biotechnology and why they are viewed as important to the goals of medicine; the ethical dimensions of biotechnology in medicine; your own views of the ethics of applying biotechnology to human health.
Assignments:	Participate in discussion. Final draft of position paper due by midnight on Sunday 7/31.

Assignment 1: Discussion

Objectives or Goals:	Discussion among participants is a major part of this course, and is essential to its success. For this reason, you are required to post at least three substantial messages each week. In order to do this, you should plan to do the reading for each section early in the week, to give yourself time to reflect on the material before you participate in the discussion. While discussion forums will stay open after the section is completed, only posts made during the duration of the section will be counted towards your discussion grade.
Assignment:	At least three substantial messages each weed in the minimum necessary for adequate participation.

Assignment 2: Position Paper

Objectives or Goals:	This assignment is designed to help you understand the issues we are discussing in this course by using the course material to support a thesis about ethics and biotechnology. You will be graded NOT on what thesis you pick to defend, but on the following considerations: (1) whether the paper demonstrates an understanding of the material we have discussed and read; (2) how well you have marshalled the material from the course in support of your view; (3) how coherent, focused, and lucid your paper is overall.
Assignments:	You will work on the same position paper throughout the course. A draft is due each week of the course. I will send you feedback on your drafts designed to help you improve your paper in time for the next due date.

Grading

Discussion:	60 points
Position paper:	40 points

APPENDIX B: COURSE SYLLABUS (ETHICS & ANIMALS)

Course Information	
Course title:	Ethics and Animals
Course number:	PHIL 547X
Course discipline:	Philosophy
Course date:	Monday, July 11, 2005 through Friday, July 29, 2005
Location:	Online.
Course Goals	
Course goals:	This course will enable participants to recognize and distinguish different views about the moral status of animals; to articulate and defend their own ideas about the ethics of using animals for food, research, and education; and to incorporate ethical issues concerning animals in their courses. This course will benefit educators who discuss or use animals in their courses or outreach efforts, as well as social studies teachers interested in current controversies about society's uses of animals.
Textbooks	
Required reading:	*All materials online.*
Week 1	
Lesson:	The moral status of animals
Date:	Monday, July 11, 2005
Objectives or Goals:	This week, we will become acquainted with different philosophical views about the moral status of animals.
Assignments:	Participate in discussion. 1st draft of position paper due by midnight on Sunday, 7/17.
Week 2	
Lesson:	Animals in agriculture
Date:	Monday, July 18, 2005
Objectives or Goals:	This week, we will discuss animals in agriculture. We will discuss arguments to the effect that animals should not be used for food, as well as arguments about the circumstances under which is is permissible to raise animals for food.
Assignments:	Participate in discussion. 2nd draft of position paper due by midnight on Sunday, 7/24.
Week 3	
Lesson:	Animals in research & education
Date:	Monday, July 25, 2005
Objectives or	This week, we will discuss whether, and under what circumstances, it is permissible

Goals:	to use animals for research and for education. We will consider developments in the protection of research animals, and the ethics of dissection.
Assignments:	Participate in discussion. Final draft of position paper due by midnight on Sunday, 7/31.

Assignment 1: Discussion

Objectives or Goals:	Discussion among participants is a major part of this course, and is essential to its success. For this reason, you are required to post at least three substantial messages each week. In order to do this, you should plan to do the reading for each section early in the week, to give yourself time to reflect on the material before you participate in the discussion. While discussion forums will stay open after the section is completed, only posts made during the duration of the section will be counted towards your discussion grade.
Assignments:	At least three substantial messages each week is the minimum necessary for adequate participation.

Assignment 2: Position paper

Objectives or Goals:	This assignment is designed to help you understand the issues we are discussing in this course by using the course material to support a thesis about ethics and animals. You will be graded NOT on what thesis you pick to defend, but on the following considerations: (1) whether the paper demonstrates an understanding of the material we have discussed and read; (2) how well you have marshalled the material from the course in support of your view; (3) how coherent, focused, and lucid your paper is overall.
Assignments:	You will work on the same position paper throughout the course. A draft is due each week of the course. I will send you feedback on your drafts designed to help you improve your paper in time for the next due date.

Grading

Discussion:	60 points
Position paper:	40 points

APPENDIX C: INTERVIEW QUESTIONS

Course Structure & Design

1. What is the role of the instructor in your courses?
2. What is the role of the students in your courses?
3. How do discussions take place in your course? How do you structure or design WebCT to promote class discussions?
4. What instructional techniques do you use to promote or facilitate discussions?
5. What is the purpose of assignments? How do they contribute to student learning?

Participation & Interaction

1. What factors might make it easier for students to participate and interact with each other in the computer conferences?
2. What factors might make it difficult for students to participate and interact with each other in the computer conferences?
3. Was there anything about computer conferencing itself that you felt helps or hinders participation and interaction from the perspectives of students and the instructor?

Knowledge Construction Process

1. How do you think asynchronous discussions among students affect their construction of knowledge?
2. Do you employ any instructional techniques or strategies to promote knowledge construction during discussions?
3. Do you typically observe any misconceptions or conflicting viewpoints by students? If so, do you attempt to clear up confusions? Explain.

Instructor Experience and Perceptions in a CCS environment

1. How long have you been teaching a course using computer conferencing?
2. What do you think about computer conferencing as an educational tool?
3. As an educator on the discussion board, what are the instructional outcomes you have experienced from online discussions?
4. What would you consider doing differently with online discussions to increase the quality of participation, interaction and knowledge construction for your future courses?

APPENDIX D: SURVEY

Name: Gender: ☐ Male ☐ Female

1. Year of birth? _______

2. What is your employment status?
☐ Not working ☐ Part-time ☐ Full-time ☐ Other: _________

3. If working, what is your occupation? _______

4. If you are teaching, what subject area do you teach? _______
☐ Elementary (all subjects) ☐ Science ☐ Math ☐ Social Studies ☐ Other

What grade level do you teach? ____
☐ K-3 ☐ 4-6 ☐ 7-9 ☐ 10-12 ☐ Higher Ed

5. How many previous web-based learning courses delivered largely through computer conference have you enrolled?
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 or more

6. Please select one below that best describes the reason you are taking this course:
☐ Enrichment
☐ Job requirement
☐ It is an elective course
☐ It is a required course
☐ Continuing education
Other: ____

7. Type of computer experience (check as many that apply)
☐ None
☐ Keyboarding (word processing)
☐ Programming languages
☐ Experience using software packages such as windows, spreadsheets, etc.
☐ Online experience using email, Internet, gopher, etc.
☐ Other (please explain) _________

8. How would you rate your experience with computers?
☐ Beginner ☐ Novice ☐ Expert

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