



The relationship of cognitive question levels to student response patterns in computer mediated instruction  
by Kimberly K Obbink

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Education  
Montana State University  
© Copyright by Kimberly K Obbink (2000)

**Abstract:**

The purpose of this study was to identify the cognitive levels of questions asked by instructors in a sample of online graduate science courses and to determine if there was a relationship between the cognitive level of the question and the corresponding student-instructor and student-student interactions that occurred.

Descriptive quantitative analyses including frequencies, comparison of means, and one-way analysis of variance were used to answer the three questions proposed in the study: ° Research Question #1: What cognitive levels of questions were asked by instructors in the NTEN courses? ° Research Question #2: What student-student and student-instructor response patterns occur as a result of specific cognitive levels of questions? ° Research Question #3: Is there a relationship between cognitive levels of instructor-initiated questions and the resulting student-student and student-instructor response patterns in the NTEN courses? The process of classifying instructor-initiated questions, calculating interaction indices, and constructing discussion diagrams is described in the study. Question levels were compared with the means of the interaction indices in order to determine if there was a statistically significant difference in the interaction patterns that occur as a result of each of the four question levels. Question levels and interaction indices were compared by content discipline and with post-course evaluation results. A supplemental course review was conducted on each of three courses in the sample in order to better identify and understand course design characteristics that might have influenced student interaction patterns and the resulting interaction indices in the courses.

There are four primary conclusions drawn from the findings in this study: 1) The majority of instructor-initiated questions in the sample of courses were found to be higher-level cognitive questions, unlike results found in traditional classroom instruction; 2) Use of higher-level cognitive questions appeared to result in increased student participation and increased probability for student-instructor interaction in the sample of courses; 3) Students were equally or more likely to interact with a fellow student as with the instructor as a result of instructor-initiated questions; 4) Discussion diagrams provide a valuable tool for visualizing and quantifying the interaction patterns that occur in the online instructional process.

THE RELATIONSHIP OF COGNITIVE QUESTION LEVELS TO STUDENT  
RESPONSE PATTERNS IN COMPUTER MEDIATED INSTRUCTION

By

Kimberly K. Obbink

A dissertation submitted in partial fulfillment  
of the requirements for the degree

of

Doctor of Education

MONTANA STATE UNIVERSITY  
Bozeman, Montana

April 2000

D378  
0612

APPROVAL

of a dissertation submitted by

Kimberly K. Obbink

This dissertation has been read by each member of the dissertation committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style and consistency, and is ready for submission to the College of Graduate Studies.

Richard Howard, Ph.D. *Richard Howard* *April 17, 2000*  
(Signature) (Date)

Approved for the Department of Education

Gloria Gregg, Ed.D. *Gloria Gregg* *April 17, 2000*  
(Signature) (Date)

Approved for the College of Graduate Studies

Bruce McLeod, Ph.D. *Bruce R. McLeod* *4-17-00*  
(Signature) (Date)

## STATEMENT OF PERMISSION TO USE

In presenting this dissertation in partial fulfillment of the requirements for a doctoral degree at Montana State University, I agree that the Library shall make it available to borrowers under the rules of the library. I further agree that copying of this dissertation is allowable only for scholarly purposes, consistent with "fair use" as prescribed in the U.S. Copyright Law. Requests for extensive copying or reproduction of this dissertation should be referred to Bell & Howell Information and Learning, 300 North Zeeb Road, Ann Arbor, Michigan 48106, to whom I have granted "the exclusive right to reproduce and distribute my dissertation in and from microfilm along with the non-exclusive right to reproduce and distribute my abstract in any format in whole or in part."

Signature *Kimberly K. Obbink*

Date *April 15, 2000*

## ACKNOWLEDGMENTS

My deepest gratitude goes to my advisor, Dr. Richard Howard and members of the Dissertation Committee: Dr. Bruce Raymond, Dr. Bonnie Sachatello-Sawyer, Dr. George Tuthill, and Dr. Larry Baker. Each of them has provided unlimited guidance, expertise and support to contribute to the successful completion of my dissertation and doctoral degree. I am also grateful to Dr. Robert Fellenz for encouraging me to pursue this goal and for inspiring so many students in the field of adult learning.

Special thanks to Dr. Sean Smith of Horizon Research for his support and contribution to this work. Thanks also to Katie Bickel for her insight regarding the use of discussion diagrams, and to all of the National Teachers Enhancement Network faculty and staff who have contributed greatly to the advancement of online learning.

I am most grateful to my parents, Jack and Dorothy Obbink, who taught me the value of education and to always take joy in the process of learning.

Thanks most of all to Vic Fesolowitz for his research experience and inspiration. I am forever grateful for his patience, persistence, prodding, and unfailing encouragement throughout this process.

## TABLE OF CONTENTS

1. THE PROBLEM.....	1
INTRODUCTION .....	1
Trends in Higher Education.....	1
Distance Learning Using Computer-Mediated Conferencing.....	2
Instructional Techniques to Promote Interaction in Online Instruction.....	4
STATEMENT OF THE PROBLEM.....	6
PURPOSE OF THE STUDY .....	7
SIGNIFICANCE OF THE STUDY.....	11
RESEARCH QUESTIONS .....	12
THE NATIONAL TEACHERS ENHANCEMENT NETWORK.....	13
History.....	13
Course Design .....	13
Evaluation.....	14
LIMITATIONS OF THE STUDY.....	16
SUMMARY.....	18
DEFINITION OF TERMS .....	20
2. REVIEW OF RELATED LITERATURE .....	24
INTRODUCTION .....	24
Context of the Problem .....	25
CURRENT UNDERSTANDING OF THE PROBLEM.....	29
Review of Studies in Online Learning .....	29
Characteristics of Online Education: Background.....	29
Computer-Mediated Conferencing.....	33
Instructional Variables in Online Education .....	34
Student Interaction in Online Education .....	37
Facilitating Interaction in the Online Environment.....	39
Moderator's Role in Facilitating Online Learning.....	44
REVIEW OF CONSTRUCTIVIST LEARNING THEORY .....	47
The Constructivist Theory of Learning.....	47
Collaborative Learning.....	50
Dialogue and Interaction to Support Learning.....	52
Challenges in the Online Environment .....	53
Implications of Constructive and Collaborative Learning for Online Instruction ..	55
REVIEW OF STUDIES ON QUESTIONING TECHNIQUES .....	61
Facilitating Interaction: The Use of Questions.....	61
Purpose of Questions.....	62
Classification of Questions.....	63
Problems with Classifying Questions .....	67
Teachers' Use of Questions.....	68

## TABLE OF CONTENTS-CONTINUED

Value of Questioning Techniques in the Traditional Classroom .....	71
Questioning Techniques and Faculty Development.....	73
Questioning Techniques in Distance Learning Environments .....	76
SUMMARY.....	82
3. METHODOLOGY .....	85
INTRODUCTION .....	85
RESEARCH DESIGN.....	86
Population to be Studied .....	86
NTEN Students .....	87
NTEN Faculty .....	88
Course Selection.....	89
Data Collection .....	90
Selection of Instructor-Initiated Questions.....	91
Question Classification .....	92
Discussion Diagrams.....	95
Constructing the Discussion Diagrams .....	98
SUPPLEMENTAL COURSE REVIEWS, POST-COURSE EVALUATIONS AND COMPARISONS BY CONTENT DISCIPLINE.....	102
Supplemental Course Reviews.....	102
Post-Course Evaluations .....	103
Content Discipline.....	103
ANALYSIS.....	104
Research Question #1 .....	104
Research Question #2 .....	105
Research Question #3 .....	105
EXPECTED RESULTS.....	106
SUMMARY .....	107
4. RESULTS .....	109
INTRODUCTION .....	109
COURSE SELECTION.....	110
SELECTION OF INSTRUCTOR-INITIATED QUESTIONS .....	111
RESULTS OF QUESTION LEVEL FREQUENCIES .....	113
Classification of Questions .....	113
Frequency of Questions by Cognitive Level.....	114
Question Level and Time In Course .....	115
Question Levels and Course Discipline	
INTERACTION INDEX ANALYSIS .....	119
Construction of Discussion Diagrams.....	119

## TABLE OF CONTENTS-CONTINUED

Sample Discussion Diagram .....	121
Calculating Interaction Indices .....	122
INTERACTION INDEX RESULTS .....	124
The Relationship of Question Levels and Interaction Indices .....	125
The Relationship of Interaction Indices and Course Discipline.....	127
COMPARISONS WITH POST-COURSE EVALUATIONS.....	130
RESULTS OF THE SUPPLEMENTAL COURSE REVIEWS.....	133
Quantum Mechanics.....	134
Course Design .....	134
Electronic Classroom Organization .....	136
Course Statistics.....	137
Discussion Diagrams and Instructor-Initiated Questions .....	138
Teaching Adolescent Nutrition .....	139
Course Design .....	139
Electronic Classroom Organization .....	140
Course Statistics.....	141
Discussion Diagrams and Instructor-Initiated Questions .....	142
Earth System Science.....	143
Course Design .....	143
Electronic Classroom Organization .....	145
Course Statistics.....	145
Discussion Diagrams and Instructor-Initiated Questions .....	147
SUMMARY OF FINDINGS .....	148
5. CONCLUSIONS.....	150
INTRODUCTION .....	150
CONCLUSIONS .....	150
Conclusions Regarding Frequencies of Cognitive Levels of Questions.....	152
Research Question #1 .....	152
Question Levels and Course Discipline .....	155
Question Levels and Time In Course.....	156
Conclusions Regarding Interaction Indices.....	156
Research Question #2.....	156
Interaction Indices and Course Discipline.....	158
Conclusions Regarding the Relationship of Question Level and Response Patterns.....	160
Research Question #3 .....	160
Conclusions from the Supplemental Course Reviews .....	161
Conclusions Regarding Post-Course Evaluation Data .....	164

## TABLE OF CONTENTS-CONTINUED

DISCUSSION OF CONCLUSIONS AS THEY RELATE TO THE LITERATURE.....	166
Instructor-initiated Questions in Online Instruction.....	166
Student-Instructor Interaction Patterns.....	168
Student-Student Interaction Patterns.....	170
Differences in Content Discipline.....	173
Differences in Course Design Factors.....	173
Perception Versus Reality in Interaction Patterns.....	175
IMPLICATIONS .....	178
Implications For Theory.....	178
Implications For Practice.....	179
Implications For Research.....	181
Peer Interaction in Computer-Mediated Conferencing .....	183
Questioning In the Online Classroom .....	183
Perception Versus Reality in Online Course Interactions .....	184
SUMMARY .....	185
6. BIBLIOGRAPHY.....	187
7. APPENDICES .....	202
APPENDIX A	
Total Pool of Courses and Courses Selected for this Study.....	203
APPENDIX B	
Sample Discussion Thread.....	206
APPENDIX C	
Sample of Electronic Classroom Organization .....	208
APPENDIX D	
Sample Questions and Cognitive Levels.....	210
APPENDIX E	
Discussion Diagram Samples.....	212
APPENDIX F	
Means of Interaction Indices for each Course.....	219

## LIST OF TABLES

Table	Page
1. Question Cues and Levels .....	95
2. Interaction Indice Formulas.....	100
3. Interaction Indices for Figure 1.....	100
4. Matrix of Indices and Question Levels.....	107
5. Frequencies of Question Levels.....	114
6. Cross-Tabulation of Question Levels and Time in Course.....	115
7. Analysis of Variance for Question Level and Time in Course.....	116
8. Cross-Tabulation of Question Levels and Discipline.....	117
9. Analysis of Variance for Question Levels and Discipline.....	118
10. Interaction Indices for Figure 2.....	122
11. Comparison of Interaction Indice Means.....	124
12. Means of Interaction Indices by Question Levels.....	125
13. ANOVA for Question Levels and Student Participation Index.....	126
14. ANOVA for Question Levels and Total Interaction Index.....	126
15. ANOVA for Question Levels and Instructor-Mediated Index.....	126
16. ANOVA for Question Levels and Instructor-Independent Index.....	126
17. Sheffe Test .....	127
18. Means of Interaction Indices for Content Disciplines.....	128
19. ANOVA for Student Participation by Discipline.....	129
20. ANOVA for Total Interaction by Discipline.....	129

LIST OF TABLES – CONTINUED

21. ANOVA for Instructor-Mediated Interaction by Discipline.....	129
22. ANOVA for Instructor-Independent Interaction by Discipline.....	129
23. Means of Post-Course Evaluation Data.....	131

LIST OF FIGURES

Figure	Page
1. Discussion Diagram Sample .....	99
2. Discussion Diagram of Question #140.....	121

## ABSTRACT

The purpose of this study was to identify the cognitive levels of questions asked by instructors in a sample of online graduate science courses and to determine if there was a relationship between the cognitive level of the question and the corresponding student-instructor and student-student interactions that occurred.

Descriptive quantitative analyses including frequencies, comparison of means, and one-way analysis of variance were used to answer the three questions proposed in the study:

- **Research Question #1:** What cognitive levels of questions were asked by instructors in the NTEN courses?
- **Research Question #2:** What student-student and student-instructor response patterns occur as a result of specific cognitive levels of questions?
- **Research Question #3:** Is there a relationship between cognitive levels of instructor-initiated questions and the resulting student-student and student-instructor response patterns in the NTEN courses?

The process of classifying instructor-initiated questions, calculating interaction indices, and constructing discussion diagrams is described in the study. Question levels were compared with the means of the interaction indices in order to determine if there was a statistically significant difference in the interaction patterns that occur as a result of each of the four question levels. Question levels and interaction indices were compared by content discipline and with post-course evaluation results. A supplemental course review was conducted on each of three courses in the sample in order to better identify and understand course design characteristics that might have influenced student interaction patterns and the resulting interaction indices in the courses.

There are four primary conclusions drawn from the findings in this study: 1) The majority of instructor-initiated questions in the sample of courses were found to be higher-level cognitive questions, unlike results found in traditional classroom instruction; 2) Use of higher-level cognitive questions appeared to result in increased student participation and increased probability for student-instructor interaction in the sample of courses; 3) Students were equally or more likely to interact with a fellow student as with the instructor as a result of instructor-initiated questions; 4) Discussion diagrams provide a valuable tool for visualizing and quantifying the interaction patterns that occur in the online instructional process.

## CHAPTER ONE

### THE PROBLEM

#### Introduction

##### Trends in Higher Education

Distance education is one of the most powerful new forces influencing the direction of higher education today (Connick in Cyrs, 1997). Rapid advances in information and communication technology have had a dramatic effect on the development and delivery of distance learning courses offered by higher education institutions (Dede, 1996). As early as 1989, the US Congress Office of Technology Assessment reported that virtually every state was interested in using telecommunications to serve education, was actively planning for distance education, or was already administering a statewide plan or system with local distance learning projects in place (US Congress, OTA, 1989). Some predict that advances in telecommunications and information technologies, coupled with changes in student demographics, point towards a future in which higher-education success will be determined by the extent to which an educational product or products are provided conveniently for the consumer at a competitive cost (Connick in Cyrs, 1997).

Student demographics in higher education are changing. Cyrs (1997) found that only 52% of college students are eighteen to twenty-one years of age, and only 15% fit the profile of the residential student who is young, attending school full-time, and living

on campus. It is only recently that educational consumers have had choices regarding what, when, where, how, and from whom they can obtain an education. As technical capabilities advance, location will offer little competitive advantage to most institutions, and students will shop for the most efficient, high-quality, affordable, and student-centered services available (Connick in Cyr, 1997).

### Distance Learning Using Computer-Mediated-Conferencing

Advances in the graphical and multimedia interface capabilities of the World Wide Web (WWW) over the past ten years are fueling the interest in distance education and have made it increasingly easier for higher education to deliver courses over the Internet. Currently, many institutions are systematically converting traditional and other forms of distance delivered courses into Web courses (Jiang, 1998). Numerous researchers (Dede, 1996, Hiltz, 1994, and Papert, 1993) noted that the expanded accessibility and graphical interface of technology such as the WWW may be appealing to students and possess the potential for improved learning. They also cautioned, however, that effective learning requires more than glitzy information technologies and that the education field would benefit from additional research in this complex and rapidly changing environment.

Wagner (1998) noted that with the wealth of new two-way technologies providing real-time, or asynchronous exchange capabilities, between instructor and student, "Distance learning practitioners tend to view interactivity as the single most significant attribute that defines a contemporary distance learning experience" (p. 417). Simply

ensuring, however, that the technical delivery mechanism provides instructor and student with the ability to interact, does not promote or guarantee a successful and quality learning experience. Traditional correspondence courses are a good case in point. Correspondence courses provide students with the ability to interact with the instructor, however, little interaction actually takes place and the course completion rate is often very low (Palloff & Pratt, 1999). Even with the use of new media, many WWW based courses are often focused on content delivery and students remain passive recipients of the information (Palloff & Pratt, 1999).

Although the literature on distance learning and electronic communication is limited, there is evidence that strongly suggests that courses taught via distance learning technologies can be at least as effective and rigorous as traditional face-to-face instruction (Hiltz, 1994). In addition, there is repeated evidence in the literature that instructional settings using computer-mediated-conferencing (CMC) technology, appear to provide additional learning benefits when compared to the more traditional distance learning delivery models such as satellite or television video broadcast (Berge, 1997a). Unlike video broadcast instruction or independent study environments, CMC creates an interactive environment in which students and instructor are able to communicate asynchronously, independent of time and location, through private messages and group discussion resulting in the active-engagement of the students in the learning process. The use of computer mediated conferencing, combined with other new distance learning technologies, enables participants to engage with others as part of a collaborative learning

network and increases the potential for direct student-instructor and student-student interaction resulting in more effective learning environments (Wagner, 1998).

Lauzon and Moore (1989) argued that new developments in communication and information technologies have shifted the emphasis away from the mass production model of distance education (one instructor delivering content to many students), to course design that is more responsive to the personal and individual needs of learners. In contrast to the passive learning and student isolation experienced in distance education delivery models such as correspondence courses, independent study, and one-way video or audio broadcast, new technologies, including CMC, offer instructors a variety of formats for engaging students in active, collaborative learning experiences (Wagner, 1998).

#### Instructional Techniques to Promote Interaction in Online Instruction

Although there are numerous studies in the area of computer mediated conferencing (CMC) in online education (Harasim, 1990a; Hiltz, 1994; Eastmond, 1995), many of them analyze CMC used as an element of traditional face-to-face courses. There are few empirical studies that examine courses taught entirely online (Berge, 1997a). These studies (Harasim, 1990a; Hiltz, 1994; Eastmond, 1995) identify the value of CMC interaction in promoting collaborative learning and positive student perceptions of their learning experience, yet few examine specific instructional techniques that might be useful for establishing effective use of CMC in online instruction (Jiang, 1998).

One specific instructional technique that has been the subject of a great deal of research in the traditional classroom is the use of questions and questioning techniques (Wilén, 1991). This research offers an existing framework that may serve as a research base for examining the use of questions in an online environment and for identifying the role that effective questioning might play in establishing a collaborative online environment. Questioning techniques and improved student-student and student-instructor dialogue and discussion appears to be well documented in the traditional classroom instruction literature (Wilén, 1991). Several recent studies in online education have identified instructor use of questions and questioning techniques as an area worthy of further study in online instruction (Jiang, 1998; Anderson & Kanuka, 1997; Palloff and Pratt, 1999). Understanding the use of questions in courses taught entirely online, where instructors and students lack the visual and auditory cues that form a common framework for face-to-face discussion, may be particularly valuable for understanding how instructors might establish active and engaging learning environments for students at a distance.

It appears that distance learning technologies will continue to provide increasingly sophisticated capabilities for student-student and student-instructor interaction, and higher education institutions will continue to expand their efforts to serve non-traditional adult students. In this regard, it is important to increase our understanding of instructional techniques that effectively utilize the technology in order to promote active, constructive, and collaborative learning in an online distance learning environment (Berge, 1997a; Jiang, 1998; USAID Policy Roundtable Series, 1999).

### Statement of the Problem

Advances in information and communication technologies are increasing higher education's ability to serve students independent of traditional campus-based instruction. Distance learning courses provide outreach to adult populations seeking both traditional undergraduate and graduate coursework as well as continuing education for professional and personal development. The graphical interface, or ability to provide images, icons, and visual symbols, as well as the broad accessibility of the WWW, has dramatically increased the development of courses delivered entirely online, in which instructors and students never meet face-to-face.

Studies have supported research indicating that students who experience higher levels of interaction tend to have higher levels of achievement and more positive attitudes than those who experience less interaction (Garrison, 1990; Ritchie & Newby, 1989; Hackman & Walker, 1990). Collaborative and active learning instructional strategies have been shown to establish a more effective learning environment, particularly for non-traditional adult learners who are often more motivated, independent, and self-directed about their learning efforts (Merriam & Caffarella, 1999; Cyrs, 1997). In addition, studies have demonstrated the effective use of computer-mediated-conferencing to promote collaborative, constructive learning environments, however, most of this research has been conducted using courses in which CMC supplements traditional classroom instruction, and not in courses delivered entirely online (Berge, 1997a, 1997b). Few studies were found that have examined specific instructional techniques that support

effective CMC dialogue and interaction in online instruction (Berge, 1997a, 1997b; Jiang, 1998; Kanuka & Anderson, 1998; McDonald, 1998).

Online forums provide potential for new forms of collaborative work, study, and community that reduce barriers of time and distance. Yet the types of interaction and means by which individuals create new knowledge in online environments are not well understood (Kanuka & Anderson, 1998, p. 57).

Research indicates that student-student and student-instructor dialogue and interaction have a positive effect on both students' course achievement and perception of the course effectiveness in both traditional and online instruction (Kindsvatter, 1988; Bossert, 1989; Vygotsky, 1962; Webb 1991; Cyr, 1997). However, no literature was found regarding ways in which instructors might effectively initiate and foster online dialogue and interaction that support collaborative learning and engage students in interaction that is more than social conversation. Several studies indicate that effective moderation of interaction and discussion is essential to the success of online instruction (Harasim, 1990a; Hiltz, 1994; Cyr, 1997), yet there appears to be limited research that identifies specific teaching strategies that might better enable an instructor to facilitate dialogue that promotes constructive, collaborative learning and achievement of desired learning outcomes in an online environment.

#### Purpose of the Study

The purpose of this study was to categorize the levels of questions being used in online instruction according to the Wilen (1991) hybrid question classification model, and to determine if a relationship existed between specific levels of questions used by instructors and the resulting student-student and student-instructor response patterns.

Although there is a wealth of quantitative and qualitative data regarding the use of questions and questioning techniques in the traditional classroom, there appears to be very little documentation collected on the use of effective questioning techniques in an online teaching/learning environment. Several recent studies (Jiang, 1998; Palloff & Pratt, 1999; Anderson & Kanuka, 1997) indicated that the instructor's use of questions in online instruction may play an important role in overall student-student and student-instructor response patterns, as well as contribute to student perception of successful learning in an online course. The authors of these studies recommended further research regarding the use of questions in online instruction. This information may prove valuable to instructors wanting to improve the online learning experience through CMC dialogue that engages students and promotes student-student and student-instructor interaction. In addition, understanding how to promote student-student discussion and collaborative learning will be important to better understand how online courses can scale in size to create effective learning environments for larger numbers of students and still be time and cost effective for instructors.

According to Wilen (1991) the two most common forms of oral discourse in the classroom are recitation and discussion, and teacher questioning is the most often used technique to facilitate student participation within these forms of interaction. In addition, the research literature indicates that recitation, characterized by the familiar teacher-initiation-student response interaction pattern, is the most predominant interaction pattern in the classroom (Wilen, 1991). Discussion, as a form of classroom discourse, is found much less frequently in the classroom and is defined by Wilen as an "educative,

reflective, and structured group conversation with students” (Wilén, 1991, p. 25). Wilén (1991) noted that the concept of conversation is key to the definition of discussion and that the interaction pattern of a discussion is much more varied than that of a recitation, with less teacher talk and much more interaction taking place between students. Several researchers have identified the value of applying the discussion method in the classroom (Wilén, 1991; Bridges, 1990; Kindsvatter, 1990; Klinzing, 1985; White, 1990; Dillon, 1988; Wilén, 1990). Gall and Gall (1990) concluded that the discussion method may be more effective than other instruction methods if achieving higher cognitive level outcomes is the goal. They found discussion to be effective in achieving five types of student learning outcomes: 1) subject-matter mastery, 2) problem solving, 3) moral development, 4) attitude change and development, and 5) communication skills. In spite of the research literature support for using the discussion technique in the classroom, Dillon (1988) conducted an extensive study on discussion and questioning in the classroom and concluded that most teachers excessively controlled classroom interaction, and that teachers defined almost all teacher-student interaction as discussion, when most should be labeled as recitation because of the emphasis on memorization of knowledge. Klinzing and Klinzing-Eurich (1988) concluded that teachers could have encouraged more student involvement by asking a few key questions instead of frequent questions, and by avoiding reaction to every student response. In this way teachers should keep the discussion from moving back to the teacher so as to reduce teacher control.

There are other indications that student-student interaction is valuable to the learning process. Inquiry learning, active learning, collaborative learning, and

constructivist learning theory all emphasize the importance of student-student interaction in the learning process (Caine and Caine, 1991; Harmin, 1994; Lazear, 1991; Marzano, 1992; Renzulli and Reis, 1985; Prutton and Hale, 1986.) Alavi, Yoo, and Vogel (1997) noted that although collaborative learning has been shown to be a highly effective learning strategy, the existing research has been conducted in traditional classrooms with geographical and temporal limits, and that little has been done to understand how to make collaborative learning expandable over time and geographic distance. In an article describing his experience with online learning, Stamps wrote that "learning about a subject is not the same as learning with someone. There's something very different about the spontaneous learning that occurs when a person's mind and thoughts are engaged with those of another person or group of people. And it's that piece that seems to be missing from much Web-based learning today" (Stamps, 1999). This study was an initial attempt to understand how teaching techniques such as questioning might facilitate student-student interaction in an online learning course.

Kindsvatter (1988) described the connection between question types and discussion patterns. Reflective discussion is defined as the highest level of discussion in terms of stimulated student thinking. It is the least structured and has the potential to generate the most student-student interaction. The purpose of this type of discussion is to engage students in high-level critical and creative thinking as they solve problems, clarify values, explore controversial issues, and form and defend positions. Low-, and high-order divergent questions are considered the most appropriate to achieve the objectives of a reflective discussion; however, this can only occur when students are motivated and

mature enough to assume responsibility for their own learning. This study examined the levels of questions used by instructors and the resulting student-student and student-instructor response patterns that occur in online courses made up of a motivated and mature graduate student population. The use of discussion diagrams, a sociogram technique, allowed the researcher to quantify the number of student-student and student-instructor connections that occurred as a result of specific levels of questions. Based on the research literature, it was anticipated that the use of higher-level cognitive questions would result in overall increased student participation, as well as increased student-student connections than the interaction that occurs as a result of questions classified in the lower-cognitive levels.

The study consisted of three parts: (a) Course transcripts were analyzed to identify and classify levels of questions posed by instructors in courses offered entirely online utilizing CMC for course communication; (b) Discussion diagrams were constructed in order to visualize and quantify the resulting student-student and student-instructor response patterns to questions in each course; and (c) Data analysis was conducted to determine if a relationship existed between question level and the resulting student-student and student-instructor response patterns.

#### Significance of the Study

The delivery of distance learning courses taught entirely online, using a combination of CMC and WWW technologies, is still a relatively new instructional environment. No studies were found that have examined the use of specific levels of

questions and the resulting student-student and student-instructor response patterns in CMC courses taught entirely online. This study contributes in the following ways:

1. Provides insight into the levels of questions that instructors are currently using in CMC online instruction;
2. Demonstrates the use of discussion diagrams to visualize and quantify the student and instructor response patterns to specific levels of questioning;
3. Identifies possible relationships between student and instructor response patterns and specific question levels; and
4. Contributes to educational theories of instruction and learning by identifying ways in which questioning may facilitate discussion and collaborative learning in an online CMC environment.

#### Research Questions

The following questions were addressed in the study:

1. What levels of questions were used by instructors in the online CMC graduate physical and biological science courses?
2. What student-student and student-instructor response patterns occurred as a result of specific levels of questions? And,
3. Is there a relationship between instructor-initiated question levels and the resulting student-student and student-instructor response patterns in the NTEN courses?

This study focused on these questions in an initial effort to begin to understand the nature of questioning techniques used in the online CMC instruction environment.

To better understand the study, the following background provides information regarding the National Teachers Enhancement Network (NTEN) courses that were used as the basis for data collection in this study.

### The National Teachers Enhancement Network (NTEN)

History: The National Teachers Enhancement Network (NTEN) at Montana State University-Bozeman has had continual funding from the National Science Foundation since 1992. NTEN has developed over 25 graduate science courses delivered to high school science teachers nationally and internationally over the past 7 years. The goal of the NTEN program is to improve teachers' understanding of the science content and ultimately improve science instruction in the high school classroom. Each course was developed by a team made up of a scientist or faculty member, inservice science teacher, and technical/design support staff. Courses were offered on a semester basis and graduate course credit could be applied to a masters degree in science education at Montana State University.

Course Design: The NTEN courses were delivered entirely online utilizing a combination of the WWW, print materials such as textbooks, manipulatives for conducting science experiments, and CMC for online course interaction. One primary goal of NTEN course design was to utilize the lowest common denominator approach to the technical requirements for the students, using minimal hardware and software requirements that would keep the courses accessible to as many students as possible. Although courses use a common CMC (FirstClass<sup>TM</sup>) software platform, the instructors

had flexibility in terms of overall course design and delivery so that each course was somewhat individual in design, based on the particular instructor and content. Common course elements included the CMC software, accessibility via Internet or WWW access, minimal technical platforms, and technical support available for students and instructors. Faculty development was offered on an individual basis, as well as through faculty group seminars in which they shared individual techniques and design, as well as assessment and evaluation results for their online courses.

Evaluation: Evaluation results of the NTEN project repeatedly show positive overall student satisfaction and have contributed to our understanding of online instruction. Horizon Research, Inc., (HRI) of Chapel Hill North Carolina had been the independent contracted evaluator for the NTEN project since its inception. In one annual report, HRI noted that "the most important lesson learned through this project is that electronic courses can be meaningful, collegial experiences for instructors and participants alike," (Smith, 1997, p. 15) and that unlike many online courses, the NTEN courses stress interaction among participants and between participants and instructor. Smith (1997) also noted, however, that not all instructors are equally adept at facilitating an interactive electronic classroom and that only a handful of experienced instructors have developed unusual expertise in this regard. Although the NTEN experience has been overwhelmingly positive, especially in terms of participants' evaluation of the online interaction, the findings are based primarily on participants' and faculty perceptions and qualitative assessment of on-line discussion.

HRI evaluations include pre-, mid-, and post-course student questionnaires, as well as follow-up interviews with individual students and faculty, and evaluation data exist for every NTEN course. Throughout the project, HRI has identified courses with various degrees of student perception of satisfaction and with various levels of student perception of the value of online collaboration with the instructor and classmates. These observations have led to HRI's interest in more in-depth evaluation and understanding of online interaction and the development of the discussion diagram model that will be used in this study.

Observation of questioning techniques that would help instructors facilitate meaningful online interactions is limited. In recent discussions, HRI NTEN evaluator Dr. Sean Smith, suggested that further study of the types of questions and questioning techniques used in the NTEN courses would be valuable (Smith, 1999b). There are several reasons that NTEN courses provide a unique platform for examining questioning in an online environment. NTEN courses are well established in the online delivery format and have been offered continuously since 1993. The NTEN evaluation has collected a wealth of data including course observations, student and faculty interviews, and student satisfaction surveys. In addition, NTEN courses are now taught primarily by experienced online instructors who, according to student evaluations, have established a successful track record for creating and maintaining meaningful online interaction that facilitates learning.

### Limitations of the Study

This study involved a multi-method exploratory and descriptive analysis which attempted to provide an initial understanding of the relationship between cognitive question levels used by an instructor and the resulting dialogue that occurred between instructor and students in an online instructional environment. There are several limitations inherent in the study:

1. Limitations of discussion diagrams: The discussion diagrams and interaction indices used to visualize and quantify the online discussion threads are designed to record the direction of interactions only. They do not provide information regarding the total number of interactions, nor do they make any assumptions or inferences regarding the quality of interaction.
2. Comparing question levels across various content disciplines: Different course content and context will understandably lend themselves more readily to various cognitive levels of instructor-initiated questions. In order to minimize the differences that are related to context, the courses used in this study were limited to graduate courses in the physical and biological sciences.
3. No ability to assume cause-effect relationships: Since the study used existing course transcripts to identify instructor-initiated questions and online discussion, there was no ability to manipulate variables. Therefore, the study was unable to identify cause-effect relationships between levels of questions and the resulting online discussion. It did, however, provide descriptive research that made observations and identified patterns regarding the possible relationship between levels of questions asked by

instructors and the resulting online interaction patterns between students and instructors.

4. Other factors related to overall classroom climate and online interaction: Methods used in this study made no attempt to control for the many factors that influence overall classroom climate and interaction among instructor and students. All courses used in the study included requirements for online participation as part of their course grade in an attempt to minimize inconsistency in students' level of motivation for participating in online dialogue. In addition, courses were all graduate level instruction serving self-selecting, non-traditional professional adult students who are motivated to obtain graduate instruction for professional development, and who are more likely to take responsibility for successfully engaging in the learning experience (Cyrus, 1997). Factors that might influence online dialogue, in addition to levels of questions asked by the instructor, are identified in the discussion section of the study.
5. The inability to identify all student and instructor responses that might relate to a specific instructor-initiated question in an electronic course record: It is possible that student responses were posted in separate course folders or conferences in the electronic classroom using a subject header that was different from the subject header of the original discussion thread. In these instances, it was not possible to identify those responses, even though they may have related to a specific question. Although the discussion threads represent the majority of the discussion and responses posted as a result of a specific question, it cannot be assumed that the thread includes all responses that might have been related to the question or that all student-student or

student-instructor interaction is represented as a result of instructor-initiated questions.

### Summary

Trends in higher education point towards the increased use of distance and distributed delivery of courses, a focus on student-centered instruction, and an emphasis on attracting a growing market of non-traditional learners who have educational needs—but who also have options (Cyrs, 1997). These non-traditional learners are increasingly able to select educational providers based on ease of course accessibility, quality of instruction, and client-centered services. As educational institutions race to capture this new market, it is important to note that research tells us very little about how to create quality teaching/learning experiences using new distance learning technologies.

One of the more thoroughly researched areas in distance learning is the use of computer-mediated-conferencing in online instruction (Berge, 1997a). The use of this tool holds great promise for creating effective, high-quality collaborative learning. Although the potential value of this delivery mode, especially for engaging students in online interaction, appears to be well documented, a review of the literature revealed very little research regarding instructional techniques that might enable instructors to use this interactive capability effectively.

The purpose of this study was to examine how cognitive levels of questions used by instructors, an instructional technique heavily researched in traditional classroom instruction, might relate to the resulting interaction patterns between students and instructor in graduate science courses delivered entirely online by the NTEN program at

MSU-Bozeman. The study was an initial attempt to determine if a relationship existed between the cognitive levels of instructor-initiated questions and the generation of online responses that encourage interactive discussion and promote student-student and student-instructor interactions in online instruction.

## DEFINITION OF TERMS

**Asynchronous Communication**

Communication conducted between two or more individuals that is not conducted in real-time, i.e. voice mail, email exchange, computer mediated conferencing, or letter writing.

**Bandwidth**

The information carrying-capacity of a communication channel.

**Browser**

Software that allows the user to find and see information on the Internet.

**Chat Groups**

Online conversations over a network in which participants type text to the rest of the group in real-time and view the postings of others as they occur.

**Codec (Coder/DECoder)**

Device used to convert analog signals to digital signals for transmission and reconvert signals upon reception at the remote site while allowing for the signal to be compressed for less expensive transmission.

**Compressed Video**

Video signals that are downsized to allow travel along a smaller carrier.

**Compression**

The reduction of the amount of data sent in a signal by transmitting only the changes in action.

**Computer Assisted Instruction (CAI)**

Teaching process in which a computer is used to enhance the education of a student.

**Computer Mediated Conferencing (CMC)**

An exchange of messages among a group of participants by means of networked computers, for the purpose of discussing a topic of mutual interest (Gunawardena, Lowe & Anderson, 1998).

### Correspondence Course

A distance learning course that relies on independent study delivery and more conventional communications methods such as mail and telephone for communication and exchange of instructional materials.

### Distance Education

The organizational framework and process of providing instruction at a distance. Distance education takes place when a teacher and student(s) are physically separated and technology is used to bridge the instructional gap.

### Distance Learning

The desired outcome of distance education.

### Distributed Learning

The use of multiple learning technologies to access resources and conduct instruction.

### Electronic Mail (e-mail)

Messages sent from one computer user to another using computer networks.

### Home Page

A document with an address on the World Wide Web that contains pointers to other pieces of information.

### Hypertext Markup Language (HTML)

The coding or programming used to create and drive Internet Web pages.

### Interactive Video

Video/audio network that allows for two or more sites to see and hear all participants on the network in real-time.

### Internet

A network of networks, global in scope, that allows the connectivity of millions of computers.

### Internet Service Provider (ISP)

An organization that provides access to the Internet and customer service, usually charging a fee.

### Listserv

An e-mail program that allows multiple computer users to connect to a single system and create an online discussion.

Local Area Network (LAN)

Two or more local computers that are physically connected.

Lurking

The observation of online interactions without actually contributing to the interaction.

Metacognitive

A conscious analysis of cognitive activity, thinking about thinking.

Multimedia

The combination of multiple forms of media to create and enhance a product, utilizing a mix of graphics, sound, video, and text.

Networks

The ability to connect multiple computers to facilitate the communication and sharing of information between machines.

Online

Activity conducted while connected to the WWW, Internet, or other computer network.

Personal Computer (PC)

A generic term used to describe many kinds of personal computer systems found at schools, homes, and offices. A stand-alone computer that does not require connectivity to a local or wide area network for use.

Real-time Communication

Communication conducted between two or more individuals in conversation at the same time, i.e. face-to-face, by telephone, or by audio or video conference.

Receiving Sites

All sites, other than the originating site, participating in a real-time telecommunicated course, conference, or meeting.

Satellite

An orbiting device used for receiving and transmitting signals from one site to multiple receivers around the country.

Server

Computers that centrally hold and dispense information across a network.

### Synchronous Distance Education

Distance education that takes place in real time but in different locations.

### Telecommunication

The science of information transport using wire, radio, optical, or electromagnetic channels to transmit and receive signals for voice or data communications using electrical means.

### Teleconferencing

Two-way electronic communication between two or more groups in separate locations via audio, video, and/or computer systems.

### Threads

Directed flows of newsgroup or bulletin board software postings. Articles and specific responses to them (and responses to the responses) are described as following a thread, and are bundled together graphically in the software's listing page.

### Uniform Resource Locator (URL)

An Internet address on the World Wide Web.

### Video Teleconferencing

A teleconference using two-way video transmission.

### Uplink

The communication link from the transmitting earth station to the satellite.

### Web-Based Learning

Distance education using extensive hyperlinks and integration of additional learning resources delivered over the World Wide Web. Web-based learning commonly includes student tracking and administrative reporting systems.

### Web Page

An Internet document designated by a specific address (URL) that usually contains various kinds of media and is linked to other web pages or Internet resources.

### World Wide Web (WWW)

The World Wide Web is a cross-platform Internet service allowing interactive access to a global collection of multimedia content "pages" linked by hypertext. (Wagner, 1998)

## CHAPTER TWO

### REVIEW OF RELATED LITERATURE

#### Introduction

The development of high performance computing and communications is promoting new media and, consequently, new opportunities for online communication and experiences that may reshape both face-to-face and distance education (Dede, 1996). Many distance education experiences that previously relied on the traditional "teaching by telling" method for instruction, are rapidly advancing towards the potential of creating "learning-through-doing environments available anytime and anyplace." (Dede, 1996, p. 4). Because opportunities for using new technologies for instructional delivery are so new, the majority of research available regarding online environments is based primarily on limited case studies and formative evaluations. Enabling students to transform archival information into personal knowledge is critical, and doing so requires educational experiences that empower knowledge construction (Dede, 1996, p.5). This study examined instructor-initiated questions in online courses, and provides an initial attempt to identify possible relationships between questioning techniques and the promotion of online dialogue that, as Dede describes, "creates educational experiences that empower knowledge construction."

There are many types of structures, motivations, and applications of online interaction that make the understanding of this medium both challenging and exciting

(Kanuka and Anderson, 1998). The following literature review outlines some of the literature that is relevant to this complicated instructional environment. The review first provides a brief overview and context of the problem addressed in this study. The review then examines three areas of study that play an important role in addressing our current understanding of ways in which instructors might employ questioning techniques in order to promote dialogue that supports collaborative, constructive learning in online instruction. These three areas include online instruction, constructive learning theory, and questioning techniques in both the traditional and distance learning environment.

### Context of the Problem

Understanding how educators can actively facilitate knowledge construction and learning in a distributed learning environment will be necessary if the potential of emerging technologies and the resulting distributed learning are to be realized (Dede, 1996). Much has been learned in the past several decades about facilitating the knowledge construction process in the traditional classroom setting. Educational reform movements abound that promote action learning, collaborative learning, interdisciplinary study, and learning-by-doing initiatives that are slowly changing our fundamental assumptions about teaching and learning in all levels of education (USAID Policy Roundtable Series, 1999).

Meaningful interaction between student-instructor and student-student in the traditional classroom is an important tool for engaging students in the knowledge construction process (Jones, Valdez, Nowakowski & Rasmussen, 1994; Wilen, 1991). This new inquiry-based environment changes the role of the teacher. He or she is a

facilitator who models inquiry and questioning, creates a student-centered learning environment, and provides lessons, learning resources, and guidance that allows students to construct personally meaningful knowledge (Galas, 1999).

In the inquiry classroom, it is not just the information that is valuable, it is how that information fits within a framework, or explains a concept. Little bits of information...are useless on their own. The way in which the information flows between teacher and student is dynamic, not a static didactic exercise. Students must relate the bits to other bits in a way that helps construct their own understanding... (Galas, 1999, p. 12).

Research is just beginning to emerge regarding meaningful interaction that promotes knowledge construction in a distance or distributed learning environment. Early distance learning researchers classified online interaction according to the agents of interaction (student, instructor, content) and the technical capabilities of the delivery mechanism such as audio or video (Wagner, 1998). For example, one-way satellite broadcast offered limited audio-only interaction capability between student and instructor and did not facilitate any student/student interaction or provide any direct student interaction with content. Two-way interactive-video networks offer both audio and video interaction between instructor-student and student-student.

CMC and emerging technologies related to the WWW offer significant advances in the capabilities and complexity of interaction between student-instructor, students-students and students-instructor-content. Wagner (1998) argued that distance learning research should re-define the notion of interaction in order to distinguish between the technical ability to provide two-way communication between instructor and student, which she defined as "interactivity", and the actual act of communication between online participants, defined as "interaction."

With ever increasing technical abilities for communication between remote individuals, the ability to facilitate communication between students and instructor is now viewed by distance education practitioners as the gold standard and minimum requirement of any distance education program (Wagner, 1998). Unfortunately, the technical ability to provide interactivity does not equate to recognizing or acting upon the potential of classroom discourse to engage students and facilitate the learning process, (Dede, 1996) or to accomplish what Wagner (1998) defined as instructional "interaction."

Real-time video-based technologies, currently used for distance learning by many education and corporate institutions, provide instructors with a format that readily replicates the traditional classroom situation. Students and instructor can see and hear one another at all sites. Observing the types of interaction that are taking place is relatively easy for the instructor or another observer. Research indicates that the majority of instruction that occurs in this environment still models the teaching-by-telling delivery method. Interaction between student-instructor and student-student was minimal, and limited to the traditional concept of communication only during the class meeting (Western Cooperative for Educational Telecommunications, 1994).

Online technologies such as CMC, supported by networked computers, facilitate communication between students and instructor in both real-time or asynchronous environments. Harasim (1990a) defined computer conferencing as "a communication system for dispersed human groups" (Harasim, 1990a, p. 41). CMC software was designed by Murray Turoff in the early 1970s in order to use the computer to structure human communication for information exchange and effective problem solving.

Educational use of computer conferencing appeared in the early 1980s. The asynchronous environment allows students and instructor to interact without requiring them to be together or in any specific place at any specific time. Students are able to post messages, public comment, and read discussions at times and locations that are convenient to them. Communication in this environment is primarily text-based, with additional computer network support (Internet, WWW, etc.) for interaction with course content and other resources. Numerous case studies noted that computer-mediated-conferencing provided the best method of interaction in the online teaching environment (Lauzon and Moore, 1989; Berge, 1997a; Harasim, 1990a) and both students and instructors repeatedly described a significant amount of interaction among all agents (student, instructor, content) in this environment.

Although the volume of interaction appears to increase in this environment, it is also difficult for an instructor to assess the quality, purpose and results of the interaction while the course is in progress. Discussions take place over long periods of time and there are often multiple discussions that occur at any given time. It is very time consuming and sometimes overwhelming for the instructor to track all the details of student interactions. Fortunately, transcripts from online interactions provide written documentation of all course communication and interaction that can be reviewed at any time (Williams, Rice & Rogers, 1988).

The next section of this literature review examines three areas of research that directly relate to our current understanding of the problem and the research questions defined in this study. The first section provides a review of the research in online

learning, including characteristics of online education, computer-mediated-conferencing (CMC), instructional variables, student interaction and facilitating collaborative learning. The second section reviews constructivist learning theories, collaborative techniques and the implications for online education. The final section reviews the research regarding the use of questioning techniques and question types in both the traditional and the distance-learning classroom.

### Current Understanding of the Problem

#### Review of Studies on Online Learning

Characteristics of Online Education: Background Distance education is commonly defined as institution sponsored instruction in which the instructor and the student(s) are physically separated (Cyr, 1997; Eisenstadt & Vincent, 1998). Over the past century, distance learning has evolved from print-based correspondence courses in the mid 1800s, to electronic technology beginning with mass radio broadcasting capabilities in the 1930s (Brown, 1994). Electronic technology advancements such as data compression for simultaneous video/audio broadcast, local area networking for connecting microcomputers, and graphical interfaces for the Internet, have continued to expand our ability to serve students who are in need of education opportunities outside of traditional learning sites and classrooms. The delivery of distance learning has expanded to include, not only print-based correspondence courses, but audio, video, and local area computer network and Internet connectivity as well.

Online instruction originally referred to computer-mediated conferencing (CMC), a system using the computer to structure, store, and process written communications among a group of persons (Hiltz & Turoff, 1993). Today, CMC is often utilized as a component of an online course; however, online instruction most commonly refers to a course that is delivered partially or entirely over a local area network or the Internet (Palloff & Pratt, 1999). Online instruction involves two primary techniques, 1) to supplement traditional classroom activity, and 2) as a primary delivery mechanism for distance learning. It is the computer conferencing or computer-mediated-instruction capability and the distance delivery mechanism of online instruction that is the primary focus for the purpose of this study.

Harasim (1989, 1990a) described the computer conferencing capability of online education as a unique expression of both existing and new attributes of the learning environment. Online education combined certain attributes of the distance learning and the face-to-face mode to create a new environment for learning. Online education is time and place independent, however, and is distinguished from many forms of distance learning by the social nature of the learning environment that it offers. Many distance learning delivery models support only a one-to-many communication environment. Similar to face-to-face instruction, the online computer conferencing environment supports interactive group communication that has been available historically only in face-to-face instructional settings.

Harasim (1990a, p.43) identified five key attributes of online education: 1) many-to-many communication, 2) place independence, 3) time independence (asynchronous),

4) text-based, and 5) computer-mediated interaction. These attributes are critical for instructional design of online courses.

Harasim credited the many-to-many communication capability of computer conferencing in online instruction with the ability to support and facilitate active learning collaborations and stated that computer conferencing “deserves serious consideration for theory building, research, and design of online educational activities” (Harasim, 1990b, p. 43). The online environment provides an effective medium for collaborative learning. Collaborative learning includes peer interaction, cooperative group work, and a learner-centered model that treats the learner as an active participant and an important contributor to the learning and cognitive development process at all educational levels (Bouton and Garth, 1983; Brookfield, 1983; Damon and Phelps, 1989; Cohen, 1984).

Eisenstadt and Vincent (1998) described the characteristics of computer-mediated-instruction as it has evolved for use in conjunction with courses offered on the WWW. They described CMC as a Web discussion system that differs in several ways from other types of interaction typically taking place on the Web. Learner dialogues on the Web are described as having the following characteristics:

- Limited number of users;
- Frequent visits;
- Closed environment;
- Focused discussion;
- Use of tutors or instructors;
- Reference to other material;

- Course management;
- Review of messages; and
- Extended interaction and collaboration with other people.

They noted that the most important benefit of locating a conference on the Web is the ability to include links to other Internet sites as part of a message. A message may then support critical thinking by bringing in supporting evidence, bringing in examples elsewhere, or providing starting points for Web exploration.

The most extensive literature review on online education was done by Berge (1997a) who reported that the characteristics, including advantages and disadvantages, have been well described and that the online environment is generally found to be a viable means for teaching and learning (Collins & Berge, 1997; Harasim, 1990a, 1990b; Hiltz, 1994, Lehman, McInerney, and White, 1993; Mason, 1993; Mason and Kaye, 1989; Wells, 1993). Russell (1999) identified and summarized 355 research reports on technology for distance education, all of which found "no significant difference" when comparing learning outcomes for students in traditional and distance education courses.

The majority of this research is based on the use of computer-mediated conferencing, which continues to be the most common definition and component of online education. Since this is a relatively new area of study, Berge noted that there is little research supporting particular theories of learning and teaching in online environments (Berge, 1997a).

### Computer-Mediated Conferencing

Computer-mediated conferencing (CMC) is the most researched area in online education (Berge, 1997a). Key advantages summarized by Berge (1997a) include:

- The asynchronous nature of an online course permits 24-hour access to other people and resources, making courses convenient for students with family or work responsibilities;
- The asynchronicity also allows students to reflect on their own responses and fellow students responses;
- Computer conferencing allows for mentoring models of instruction and will change the roles and dimensions of students, teachers, curriculum and instruction;
- Computer conferencing permits interdisciplinary problem solving; and
- Computer conferencing fosters multiple perspective approaches to teaching and learning.

Hiltz's (1987) evaluation of the Virtual Classroom is one of the earliest documented studies in the CMC field. Her research involved five pairs of matched sections of the same courses taught in the virtual classroom (VC) and in a traditional classroom (TC). Courses used the same teacher, text, printed materials, and midterm and final exams. Questionnaires and automatic monitoring were used to collect outcome data in addition to feedback from faculty, student interviews, and content analysis. Pre-, and post-course questionnaires were the primary data source. Major findings from the study indicated that there were no consistent differences in scores measuring mastery of material taught in the virtual and traditional classroom. In addition, correlation analysis

of survey data and qualitative data from individual interviews, revealed that students who experienced high levels of communication with other students and with their professors (who used a “collaborative learning” approach to their coursework) were more likely to judge the outcomes of VC courses to be superior to those of traditionally delivered courses (Hiltz, 1987, p. 167).

Other studies support the finding that computer-mediated conferencing is effective for delivering courses at a distance, although the majority of this research was conducted using single or few online courses, or with courses that were taught in a traditional fashion using CMC as a supplement to instruction. Fabro (1996) examined survey and interview data from twenty-four students in a computer conferencing graduate course and found that computer conferencing can enhance and promote collaboration and critical thinking in a distance education setting. Bourne et al. (1997) also examined the effectiveness of asynchronous learning networks for delivery of online courses. This study examined a three semester-hour course offered by Vanderbilt University entirely online with all materials available in textbooks and on the Web. The study found that the online students learned as much as students in the traditional course, 80% liked the asynchronous delivery, and conferencing was considered important in peer-to-peer learning.

#### Instructional Variables in Online Education

Although early studies were focused on the viability of online instruction when compared to the traditional classroom, new studies that examine instructional variables in courses taught entirely online are starting to appear. Cairns (1994) used a qualitative

study to examine the facilitation process in post-secondary settings. Interviews were conducted with twelve teachers who had taught a variety of disciplines using computer conferencing as the primary medium. Components of the facilitation process that were identified by the teachers included: the experience of using computer conferencing; creation of a safe community for learning; the teachers' awareness of the learning capabilities of the adult learner; and teacher roles. The study results indicated that computer conferencing enabled the teachers to utilize a style of pedagogy that included individualized instruction, self-directed learning, and student-directed learning. In addition, all of the teachers expressed an interest in continuing use of the medium.

Berge (1997b) and Collins and Berge (1997) conducted similar studies. Berge (1997b) surveyed forty-two post-secondary online teachers in order to identify characteristics that educators might systematically employ to improve their online teaching. Based on the results, Berge identified strategies used by online instructors in their day-to-day teaching. The majority of teachers indicated that these strategies were more student-centered than teacher-centered, and that predominant methods included discussion, collaborative learning activities, and authentic learning activities such as case studies, projects, peer critique, and problem-based activities. Most teachers indicated that guiding learning by asking the "right questions" was more important than being able to give students the "right answer."

Collins and Berge (1997) surveyed electronic discussion group listeners and moderators regarding their perceptions of their roles, responsibilities, and tasks. Results indicated that a moderator would assume different roles at different times for different

lists. Role descriptions ranged from filter, firefighter, facilitator, administrator, editor, promoter, expert, helper, participant, and marketer. Listowners, users, and moderators preferred that discussions be moderated because a moderator can help keep discussions active and focused, hold down "flames," and help digest/edit posts.

Eastmond and Ziegahn (1995) used their own experiences to outline essential considerations and tasks for instructional development with CMC in designing an adult online course. Elements include: design models; a match of content; teaching and learning in an online environment; allocation of resources; preparation of course syllabus; design of various instructional activities that will support students with different backgrounds and learning styles; and evaluation of student learning. Although these suggestions may be useful for online course design, the elements are not based on any empirical evidence obtained from their course implementation.

Jiang (1998) surveyed course participants from 19 post-secondary courses taught entirely online through the SUNY Learning Network. Survey results from course participants were used to quantitatively examine how instructional design, instructional management, and demographic variables were related to students' perceptions of their learning experiences in the online environment. In addition, Jiang conducted an in-depth qualitative analysis of three courses in their entirety in an attempt to define optimal web-based environments for online learning and to reveal instructional factors that might have contributed to students' perceived learning. Jiang found that socio-collaborative course environments are more conducive to perceived learning and that grading instruction and requirements for discussion participation were statistically and positively

related to students' perceived learning. Students showed higher achievement in courses in which instructors placed a strong emphasis on online discussion. Results of the study showed that a certain amount of instructional support in the form of content presentation and response is needed for better perceived learning. Students prefer a balance between behaviorist and constructivist approaches to instruction in the online environment.

### Student Interaction in Online Education

Numerous studies have analyzed participant interaction in computer conferencing; however, many of these use data from courses in which computer conferencing supplemented traditional classroom instruction. Simon (1992) described a pilot experiment organized for in-service teacher training courses in Spain. Learners received print-based course content and orientation materials. They worked through the materials, practiced navigation through the software, carried out exercises in the application, sent solutions to a tutor, and answered theoretical questions posed by a tutor. The courses included three face-to-face meetings with the entire class. Simon used both qualitative and quantitative analysis consisting of pre-, and post-questionnaires, as well as hard copies of the messages entered in the computer conference. His findings indicated that only 26.8% of the students logged in frequently and that students relied more on the use of a distribution list for important messages or notifications instead of the conferencing system. Qualitative analysis of the study revealed that the largest percent of messages in each course corresponded to responses to activities and questions posed by learners, but that there were few messages that indicated peer interaction or evidence of collaborative

learning. Students indicated that lack of time and seeming unimportance of participation in conferencing determined their use of the computer conferencing.

Hartman and others (1995) compared the interaction in freshman writing classes at Carnegie-Mellon University that had access to network communication tools to the interaction in similar classes with strictly traditional modes of communication. Both traditional course and courses with network communication tools used collaborative approaches to instruction. The study found that courses with computer conferencing had an effect on the distribution of teachers' attention in the classroom. Less able students communicated more with teachers and classmates electronically than more able students did. More experienced teachers were also found to utilize electronic communication more effectively in terms of encouraging students to communicate with one another electronically.

Other studies indicated a relationship between teachers' experiences, beliefs and practices, and successful student interaction and collaboration in online education. Simon (1992) identified several success factors involving computer conferencing. Study results indicated that planned structures to tasks that give learners a clear objective, minimum requirements to insure student participation, and tutor interventions are all important for creating a collaborative learning environment.

Macabe (1977) studied the level of student interaction in three online courses and found that computer conferencing could support a range of learning environments from a traditional teacher-led symposium to a participatory workshop model. Participants attributed variety to the teachers' beliefs and practices rather than factors related to the

technical medium. Although the data showed that a few students dominated the majority of online discussion, the information also suggested that teachers' frequent participation and explicitness about their expectations are essential factors in a healthy online discussion.

In a review of evaluation methodologies for computer conferencing applications, Mason (1992) found that most computer conferencing research stops with quantitative analyses of messages sent and by whom, number and time of logons, and number of replies. Although there are numerous qualitative studies that attempt to analyze the specific content of conference messages (Levin, Kim, and Riel, 1990; Mason, 1992; Henri, 1992; and Newman et al, 1995), each of them has developed its own complicated framework for message content analysis that does not provide a theoretical model relevant to this study.

### Facilitating Interaction in the Online Environment

The rapid development of information and communication technologies has provided educators with a number of new opportunities for facilitating interactive modes of instruction and communication with distributed students. Real-time communication is now supported by a number of technologies. Two-way interactive video, sometimes referred to as compressed video, allows participants to see and hear one another in real-time at multiple distant locations. Streaming video over the Internet or high-speed phone lines also provides two-way video and audio capabilities. Real-time chats allow students to "talk" in real-time by writing to one another online using networked computers.

Other communication software and hardware advancements provide distributed individuals with the ability to communicate independent of time and location, or asynchronously. Listservs and email are examples of asynchronous communication between multiple students. Computer mediated conferencing (CMC) simulates a classroom situation online by allowing "an exchange of messages among a group of participants by means of networked computers, for the purpose of discussing a topic of mutual interest" (Gunawardena et al., 1998, p. 139). Unlike listservs, that broadcast email messages to a group of subscribers, CMC provides the ability to group (thread) messages chronologically and by specific topics, as well as to post private messages to an individual. A wide variety of software programs are now available and in-use for the purpose of providing computer-mediated communication (usually via the Internet) for distance learning students enrolled in a class or program.

Gunawardena et al. (1998) noted that CMC conferences provide an unparalleled opportunity to observe knowledge construction in progress by transcript analysis. All interactions are recorded by the software, which provides a transcript similar to audio-taping and transcribing all interaction in a traditional classroom. In a review of the literature, Gunawardena et al. (1998) found that although participant satisfaction and patterns of participation in CMC have been adequately observed, there is not satisfactory research related to how to assess the quality of the interactions and learning experience in the CMC environment.

Bichelmeyer and Kiggins (1998) found that in a study of web-based instruction supplementing a single traditional course, learners found the use of CMC to be enjoyable

and worthwhile, and requested that it be used in the future. Minimal negative comments from both students and instructor were primarily related to technical issues surrounding Internet access, account access, line speed, and initial learning curve for using the software. The instructor reported that students submitted higher quality case study reports in terms of content and thoroughness when using CMC communication. Faculty also felt that CMC encouraged greater planning and structure for courses and provided a group memory of course materials and interaction. The major disadvantage described by faculty was the increased amount of time involved in teaching using this medium. Bichelmeyer and Kiggins (1998) determined that CMC fostered student interaction, and encouraged participation by all students, because CMC allows even the quiet, shy, or contemplative students equal opportunities to participate and make valuable contributions.

Shearer and Rose (1998) described preliminary observations of a distance-learning course utilizing the FirstClass™ CMC software. Similar to Bichelmeyer, Shearer and Rose found that faculty indicated an increase in the amount of time required to teach the course, and an increase in the quality of the students' final projects. The instructor also believed that s/he got to know the students more personally than in a traditional course, had a better understanding of students' goals for the course, and was able to interact more with students in the CMC environment than in a traditional classroom. Students indicated a general level of satisfaction and their negative responses were associated with technical difficulties. Shearer observed that most students simply posted responses to study questions and did not read the responses of others. He also

noted that students having difficulty appeared to review the responses of others before contacting the instructor. There were more interactions on graded assignments and some students felt that the ability to conduct a real-time chat within the CMC software allowed them more personal interaction with other students. Observing instructor behavior Shearer noted that the instructor was online five days a week, for five to seven hours per week. The instructor also read all messages and responded to all questions posted by students.

Unique forms of classroom talk were observed in the CMC environment (Hegngi, 1998.) Fetterman noted that teachers and learners are insecure about roles in online interactions (as cited in Hegngi, 1998) and Hannafin and Park's (as cited in Hegngi, 1998) research on human computer relationships revealed that learning is facilitated when computer interfaces are familiar and easily understood (as cited in Hegngi, 1998). In live classroom interaction, Cazden and Mehan (as cited in Hengngi, 1998) found that Initiation-Reply-Evaluation (IRE) was the most common sequence in teacher-led speech. Quinn, Mehan, Levin and Black examined CMC interaction and found that it differed from the traditional classroom IRE sequence in three ways (as cited in Hegngi, 1998.) First, there was a temporal difference between initiations and responses in which time gaps did not interrupt the flow of conversations. Second, they found a topical difference with half-as many teacher-directed questions and a greater climate of open participation. The third difference was structural, in that the interaction did not follow the IRE pattern and students initiated more discussion. The results, however, showed that students did

not evaluate either instructor or peer responses, and the instructor had the strongest influence on the direction, tone, and outcome of the interaction.

Wagner (1998) noted that previous research on interaction in a distance-learning environment was limited because of the technology's inability to facilitate interaction. Moore (as cited by Wagner, 1998) established the most commonly known schema for classifying interaction in distance learning. His schema identified three types of interactions: 1) interactions between instructor and learner, 2) interactions among learners, and 3) interactions between learners and the content they are trying to master. Wagner pointed out that this schema only identifies the direction of the interaction between agents, and that new technical capabilities now allow us to look at interactions beyond classifications that are based solely on the agents involved.

Wagner (1998) proposed that classification of interaction should focus on outcomes so that interaction can more effectively serve as a means to the ends of learning and performance improvement. By focusing on outcomes, she argued that it is easier to see the impact that interaction has on the learner. These impacts include: enabling the active learner to participate in the instructional process; allowing learners to tailor the learning experience to meet specific needs; enabling learners to clarify a new idea; and promoting intrinsic motivation by highlighting the relevancy that new information may have under specific circumstances. Wagner identified 11 outcome-based categories for interaction in a distance-learning environment. They include interaction for: participation, communication, feedback, elaboration, learner control/self-regulation, motivation, negotiation, team building, discovery, exploration, clarification, and closure.

In 1998 Wagner concluded that the best way to design an interactive learning experience is to first consider the goals and objectives of the learning experience and then to select strategies and tactics needed to achieve the goals for the specific audience and given conditions; and the result: interaction, the planned-for outcome of a well designed instructional experience.

### Moderator's Role in Facilitating Online Learning

The role of the moderator appears to be essential for creating a stimulating and supportive online learning environment (Anderson and Kanuka, 1997; Berge, 1997b; Hiltz & Turoff, 1978). Tagg (1994, p. 40) defined the moderator as one that motivates, provides support and stimulates, guides or “weaves” the topic in order to keep it on the right track, provides leadership, coaches students, facilitates discussion, and secures continuity. All this is done in an attempt to “humanize the technology” in a medium where it is difficult to maintain an overview of the entire process.

Hiltz and Turoff (1978) first identified the role of the moderator, which has been confirmed by Harasim (1995), Berge (1997a, 1997b), Mason (1997), and Klem & Snell (1996). Mason (1997) proposed that the role of the moderator in any online conferencing activity requires special responsibilities in both the technical and facilitating sense. At the educational level the moderator guides the discussion, stimulates participation, and offers intellectual leadership. Harasim, Hiltz, Teles, and Turoff (1995) determined that when moderators are actively involved by responding regularly, posting new material, and encouraging activities and discussions, students will respond with enthusiasm and regular participation.

Anderson and Kanuka (1997) studied the level of participation and perceptions of effectiveness from 23 adult education and community development experts participating in an online professional development forum. Although all participants agreed that the online forum accomplished the course goals, they perceived the experience as less effective than a traditional face-to-face professional development experience. Participants indicated that they were more limited in their ability to communicate than in a face-to-face setting and that it was more difficult to socialize. Anderson and Kanuka noted, however, that those who participated more actively in the online discussion expressed higher levels of satisfaction and attributed greater value to the online experience. They concluded that limitations in ability to communicate or socialize electronically may be overcome by more creative moderating techniques that foster collaborative learning and build learning communities; and they suggested that further research be done to determine if effective moderation can facilitate movement from reactive to fully interactive online communication.

Kelmm and Snell (1996) also addressed the notion that the moderator must promote collaborative learning in online instruction. They described collaborative learning, wherein small interdependent groups work together as a team to help each other learn, as an approach that requires participants to use higher level thinking skills in order to critically evaluate and apply instructional materials. Kelmm and Snell proposed that it is the moderator's responsibility to engage students in tasks that require them to use higher-level learning processes and that these processes are leveraged if groups work collaboratively.

The importance of the instructor's role in facilitating collaboration in the online learning environment is supported by others. Comstock and Fox (1996) argued that problems facing workers and managers today cannot be solved by the knowledge of one individual, and that the learning community created through online instruction can expand individual knowledge through interactions with a diversity of other learners. Kanuka and Anderson (1998) proposed that "social constructivism" is "currently the most accepted epistemological position associated with online learning. The assumption is that knowledge is grounded in the relationship between the knower and the known. Knowledge is generated through social intercourse and through this interaction we gradually accumulate advances in our level of understanding." (p. 60)

Anderson (1996) reported that the online forum represents a complex learning environment in which group collaboration is practiced in a technologically mediated environment, and that the resulting interaction can lead to the creation of vibrant communities of learners. Driscoll (1994) also noted the capacity of the computer to provide an interactive environment that creates an effective means for implementing strategies that support the social construction of knowledge while simultaneously creating an archive of this interactive process. With this apparent emphasis on constructivist learning theory in online instruction, it is appropriate to conduct a brief review of the literature regarding constructivist learning theory, collaborative learning techniques, and their implications for the online teaching/learning environment.

## Review of Constructivist Learning Theory

### The Constructivist Theory of Learning

According to constructivist learning theories, how knowledge is constructed will depend on what is already known. What an individual knows depends on the kinds of experiences that he or she has had and how they come to organize these experiences (Kanuka and Anderson, 1998). The constructivist learning theory, or how learners “come to know” (Fosnot, 1992, p. 168), was derived from early research on developmental psychology, particularly that of Piaget. Constructivists believed that organisms “have an innate need to organize and adapt to their environment simply for survival, thus they also accommodate their structures to their environment. In other words, experience, knowledge, and hence truth, are always a result of the constructed cognitive structures used in interpreting” (Fosnot, 1992). Duffy and Jonassen, 1992) described constructivism as the belief that meaning is imposed on the world by us, rather than existing in the world independently of us. Learning is described as a constructive and active process in which the learner builds an internal representation of knowledge—a personal interpretation of experience that is constantly open to change (Bednar, Cunningham, Duffy & Perry, 1992; Cunningham, 1992).

Unlike the behaviorist or objectivist theory of learning, in which meaning or a universal reality exists in the world independent of experience, (Fosnot, 1992), Bednar et al. (1992) argued that multiple perspectives and individual experience play an important role in the construction of meaning. “Conceptual growth comes from the sharing of multiple perspectives and the simultaneous changing of our internal representations in

response to those perspectives as well as through cumulative experience.” (Bednar et al., 1992, p. 21) An individual is considered able to store experiences and construct new understandings based on past experience (Duffy and Jonassen, 1992). Prior understandings and experiences, therefore, play an important role in the knowledge building process.

Constructivist learning theory proponents maintain that students should select or develop their own learning strategies, and often their own goals and objectives (Winn, 1992). Unlike the behaviorists, who support instruction that involves the direct presentation of content/knowledge, constructivists advocate instruction that guides or coaches a student; that provides students with access to real-world examples; and that proposes problems to promote reflective thinking (Duffy and Bednar, 1992), in an environment rich in tools to enhance communication. Winn (1992) described constructivist instructional strategy as one that gives the student much of the responsibility for deciding what to learn and how to learn it, and then supports the student in his or her decision. From the constructivist viewpoint, learners actively create knowledge and meaning through experimentation, exploration, and the manipulation and testing of ideas in reality; and the interaction, collaboration, and feedback from others assist in determining accuracy and application of ideas (Palloff and Pratt, 1999).

Although constructivists convincingly argue the weaknesses of traditional transmission of instruction involving direct presentation of content, (Collins, Brown, & Holum, 1991; Bednar et al., 1992), it is not obvious that a strict constructivist instructional approach is always appropriate for either the traditional classroom or online

teaching environment (Jonassen, 1991). In reality, most instructional designers, theorists, and instructors assume a practice that falls somewhere between the continuum of behaviorism and constructivism (Jonassen, 1991). Jonassen (1991) described three levels of knowledge acquisition (introductory, advanced, and expert) and proposed that instructional strategies for each level fall at a different place on the behaviorist/constructivist continuum—with introductory learning requiring more behaviorist instructional strategies, and expert learning moving towards the constructivist end of the continuum. In later work, Jonassen (1995) described the importance of the instructor as facilitator in the construction of learning environments that foster personal meaning-making, as well as the social construction of meaning through interactions with communities of learners. Instructor facilitated interactions with communities of learners is considered preferable to instructor interventions that control the sequence and content of instruction.

Additional support for establishing a necessary balance between the two learning theories was argued by Allen (1992) and Perkins (1992). In reviewing work done by early constructivist theorists Lakeoff and Johnson, Allen (1992) noted that they did not argue against a shared understanding of reality. Rather they agreed that there is a certain level of commonality in human interpretations and understanding, admitting it is possible that there are some past and tested human experiences that might be conveyed to the learners. Perkins (1992) proposed two types of constructivist instruction that also balance the behaviorist and constructivist approach. BIG stands for “beyond the information given” (Perkins, 1992, p. 49) and is described as a moderate constructivist

approach involving some direct introduction of concepts. WIG stands for “without the information given” (Perkins, 1992, p. 49) and is considered a more radical constructivist model in which the instructor provides no direct instruction and no correct answers.

### Collaborative Learning

Harasim (1990b) identified collaborative learning, highlighting the constructivist notion of social and intellectual interaction, as a valuable starting point for addressing ways in which computer conferencing and CMC systems can enable us to enhance our social and intellectual capacities. Collaborative learning is an instructional approach or strategy that integrates social skills objectives with academic content objectives, originating from Vygotsky’s cognitive research and the idea that “human higher mental functions are products of mediated activity” (Vygotsky, 1986, p. xxvi). Vygotsky (1986) proposed that cognitive processes are developed through social interaction and that individual consciousness is built from the outside, through relations with others. Joint participation in an activity permits learners to display, share, practice, and modify cognitive processes. His views on the function of human interaction with an emphasis on process, rather than product, provided the foundation for collaborative learning (Jiang, 1998).

Vygotsky emphasized dialogue between teacher and student and student and student as an important instrument in building new conceptions (Jiang, 1998). Dialogue and its importance in collaborative learning was later extended by other collaborative learning proponents including Vygotsky, 1986; Johnson, 1986; Johnson and Johnson, 1989; and Slavin, 1990 (Jiang, 1998). Presseisen (1992) identified several

characteristics of cooperative learning that are related to the importance of dialogue between and among students:

1. Presseisen (1992) argued that the heart of collaboration is a group processing of information and an exchange of the thinking involved in the cognitive processing. Students must explain how they reach a conclusion or arrive at an answer.
2. Cooperative learning requires students to share how they think. Through dialogue, learners become more aware of their own thoughts as tools to apply tentatively to given problems, and in the dynamic exchange between and among their classmates, teach themselves more powerful dimensions of thinking (Palincsar and Brown, 1988; Presseisen, 1992).
3. Cooperative learning also provides an environment for mastering two of the most essential skills in learning to be an effective thinker: posing questions and formulating significant problems. Palincsar and Brown (1988) suggested that predicting, questioning, summarizing, and classifying are group learning skills that ultimately help students integrate new information with the prior knowledge they have already mastered (Presseisen, 1992, Jiang 1988).

This emphasis on the linguistic exchange between and among students, and between students and instructor, identified in Presseisen's characteristics, has particularly relevant applications for instructional design and support for learning in the online environment.

### Dialogue and Interaction to Support Learning

Dialogue and interaction support collaborative learning and are essential to the learning process (Presseisen, 1992). Lauzon (1992) defined learning as a “transactional process, a process that is characterized by the exchange of ideas, thoughts, and feelings between and among people, resulting in new ways of viewing the world or in new ways of acting.” Hiltz (1987) argued that interaction with others facilitates many higher-order intellectual skills. This is supported by Lauzon and Moore (1989) who defined interaction with the instructor and other learners as necessary in order to facilitate the integration of newly acquired knowledge into one’s own knowledge framework. In addition, they agreed that higher-level learning and integration is most effectively attained through the process of dialogue, and that this can be accomplished best in a distance mode via computer conferencing. Unlike real time instruction that is broadcast, and which simulates the traditional classroom model, the digital asynchronous online environment allows students and instructor to send, receive, reflect, and respond to messages posted to individuals, small groups, or to the entire class at any time throughout the course (Harasim, 1990b). Numerous case studies and anecdotal data (Shearer & Rose, 1998; Smith 1998; Bichelmeyer & Kissins, 1998) described the volume of interaction in online courses. In addition, students in CMC courses report that they are more open and willing to communicate in the online environment, and attribute this to the text based, asynchronous delivery that may reduce many of the social cues that often accompany face-to-face interaction. The potential for collaborative learning is increased

when the technology facilitates interaction beyond the traditional class session (Dede, 1996; Hiltz, 1994; Wagner, 1998).

The importance of written dialogue, student-student, and student-instructor interaction appears throughout the literature on online teaching and learning (Harasim, 1990a; Berge, 1997a; Jiang, 1998; Cyrs, 1997). Palloff and Pratt (1999), in their manual for successful online teaching, focused largely on the concepts of constructivist and collaborative learning in designing an effective online course. One chapter is devoted to the use of online discussion as a means for promoting collaboration and they suggest that when students engage in discussions with each other, rather than with the instructor, the possibilities for collaborations grow significantly. Their suggestions for promoting collaboration in online discussions include: 1) development of shared goals, 2) posting introductions and learning expectations, 3) creating teams for small-group discussion, 4) use of questions that encourage students to bring their life experiences to the classroom, 5) using dialogue as a form of inquiry, and 6) sharing responsibility for facilitation.

#### Challenges in the Online Environment

“Generating and supporting dialogue within an online course, or using a conferencing system as a supplement to face-to-face teaching, is a serious challenge” (Eisenstadt & Vincent, 1998, p. 124). Multiple studies have identified 1) interactive modes of instruction and 2) teacher as facilitator as two factors required for successful and quality distributed learning opportunities (Jones et al., 1994; Cyrs, 1997). There is little information, however, regarding specific skills that enable instructors to facilitate meaningful dialogue and online interactions (Berge, 1997a, Jiang, 1998). Quantity and

quality of interaction are difficult for an instructor to assess in the online instruction environment. Traditional classrooms or real time video/audio distance learning environments provide the instructor with an immediate sense of student interaction. An instructor finishes an interactive video class session with a personal impression regarding the amount and quality of interaction that took place during the class, similar to an impression that might be gained from a traditional classroom experience.

In the asynchronous online environment an instructor is able to readily observe and identify the student(s) most often posting messages. Monitoring types and quality of interaction in the online course, however, is much more difficult due to the volume and asynchronous nature of the interaction. It is especially difficult to observe the "lurking" students, who may actively follow the online discussions without contributing, and who perceive themselves as profiting from the online interactions even when they do not actively contribute to the conversation. (Gunawardena et al., 1998) In addition, the ability to conduct simultaneous discussion threads on different topics, lack of a common class time and location, and student ability to start discussions make it difficult for the instructor to have a clear understanding of the kinds of dialogue and discussion that are continually taking place.

Fulford and Zhang ( 1993) noted that interaction may be more difficult to achieve in distance courses than in traditional classes. They suggested that the miles between students and instructor can restrict interaction. Since learners and teachers are not in the same room, subtle interactions through body language are lost and learner perceptions of the amount of interaction may be altered. They also suggested that higher levels of

interaction may be needed to motivate and satisfy learners in the distance learning environment.

### Implications of Constructive and Collaborative Learning for Online Instruction

A more active learning model such as that described by social constructivist learning theory appears to be the model of choice for the online distance learning environment (Palloff & Pratt, 1999; Cookson, 1999). Elements of time, distance, and limitations of access make it more difficult for the instructor to be in direct control of how or what is being learned. Learners, in some respects, are left to their own devices to make sense of the course content. The instructor supports this process “through the use of collaborative assignments, facilitation of active discussion, and promotion of the development of critical thinking and research skills. The outcome is an environment rich in the potential for collaborative learning and the social construction of meaning” (Palloff & Pratt, 1999, p. 17).

Due to the limitations of current online technologies and limited available bandwidth for the simultaneous delivery of video, audio, graphics, and text, the online course environment creates a need to provide students with alternatives to the traditional lecture delivery of content. In the constructivist viewpoint, this limitation of the technology might ultimately be seen as a positive aspect that forces instructors to think differently about the delivery of content. The increasing access to resources offered by the WWW, enables learners to take more responsibility for their own learning, to identify goals and objectives, and to access and utilize information and resources for constructing new

knowledge and understanding. In addition, online courses provide students with text-based opportunities for interaction, often using some form of CMC, which establishes an environment conducive to social construction of meaning.

Palloff and Pratt (1999) noted that many online courses they observed are, unfortunately and typically, content-and-faculty-facilitator driven, just as they are in the traditional classroom. "In many ways they perpetuate an old model of teaching and learning, wherein participants are producing pieces of work that are to be evaluated and commented on by an expert." (Palloff and Pratt, 1999, p. 18) They proposed that in order to be successful, the online learning environment must subscribe to a new paradigm, one that creates an equality of student-student and student-instructor interactions. "The most powerful experiences are those in which interaction occurs throughout the group instead of between one participant and the facilitator within a group setting" (Palloff and Pratt, 1999, p. 19).

Social constructivist learning theory, combined with collaborative learning strategies, is facilitated by computer-mediated communication (Harasim, 1990b). According to Harasim, CMC supports an active and collaborative construction of meaning and ideas. The text-based environment generates a database or web of ideas and responses which often improves the participants understanding of the topic under consideration. Exposure to both positive and negative feedback stimulates cognitive restructuring in response to new information and to disagreements or challenges encountered in the group discussions (Harasim, 1990b).

The diverse backgrounds of the online students play an important role in supporting the social constructivist and collaborative nature of online learning. Students in the online courses are often spread over a large geographic area and bring rich and varied experiences to the online classroom. These divergent viewpoints and experiences provide a rich backdrop for enabling students to develop, compare, and understand multiple perspectives and to construct new knowledge based on analysis, evaluation, and synthesis of the collective information (Bednar et al 1992).

There are many studies that support the viability of constructive and collaborative learning in the online environment (Hiltz, 1990; Simon, 1992; Fabro, 1996; Berge, 1997b). In early research, Harasim (1990b) described online education as supporting a many-to-many learning environment. This notion was later expanded by Kaye (1992a) who saw online education as an environment that could also support a collaborative construction of meaning. He redefined the word "collaborate" or co-labor, based on what students do in an online course. He defined "collaborate" as working together with shared goals and an explicit intention to create something new or different through the collaboration, regardless of whether learning is the primary goal or an incidental outcome.

Kanuka and Anderson (1998) conducted a study of participant interaction in a two-week online professional development CMC forum. Using the constructivist interaction analysis model developed by Gunawardena, Lowe, and Anderson (1997), the authors conducted transcript analysis in order to categorize interaction into five levels of knowledge construction: sharing/comparing of information; discovery and exploration of

dissonance; negotiation of meaning or co-construction of knowledge; testing and modification of proposed synthesis; and phrasing of agreement, statements and applications of the newly constructed meaning. The study found that the majority of messages in the professional development forum were coded to the first phase of knowledge construction or "sharing and comparing" of information. The authors noted that this level of interaction is common in the face-to-face, informal dialogue that occurs at professional development activities. They also indicated, that lacking a subject matter expert to draw out and develop new concepts, and the absence of a learning environment that demands a greater understanding of content, participants may have been unmotivated to participate above a safe and comfortable level. Kanuka and Anderson offer several additional interesting hypotheses regarding why the majority of interaction was conducted at the lowest level. They caution that the construction of knowledge may not be an observable activity that can be accomplished through text-based transcript analysis and that the dialogue might have resulted in the construction of knowledge that was not shared with other participants or that occurred after the forum ended.

Understanding interaction and collaborative learning in online instruction will require research in online communications among and between learners, instructor, and the group as a whole. Little research exists, other than anecdotal, that answers the question of whether groups develop online, and whether a predictable pattern of communication exists online or can be discovered due to the complexity of interactions (McDonald, 1998). In an attempt to understand group dynamics and development in CMC courses delivered online, McDonald (1998) conducted an in-depth transcript

analysis on a graduate online course offered by the University of Wisconsin-Madison. Although the course was delivered almost entirely online, students did have the opportunity to meet face-to-face during several early informational meetings in which they learned to use the CMC software. Students were randomly divided into discussion groups early in the course, and McDonald was able to compare online interactions between the three groups. The results showed that 75% of all speech segments in online discussion during weeks 3, 8 and 11 of the course were coded as "interpersonal." The frequency of interpersonal speech segments decreased over time across all three groups; however, it continued to be prominent throughout the course. Each interpersonal speech segment was also coded for "intent" according to the author's intention in posting the comment. Intent categories included involvement, control, openness, solidarity and conflict. All groups demonstrated significant upward trends in "openness" segments over time, and significant downward trends in "involvement" and "control" comments. McDonald concluded that these findings show that there is, indeed, a pattern of group development in online courses with an increase in students' willingness to share themselves and reach out to other group members over the course of time. This finding is also consistent with results described in the literature for face-to-face groups and McDonald noted that the fact that communication is computer-mediated does not seem to have a discernible effect on group development in online courses. She also cautions that this study involves analysis of only three weeks of interaction in a single online course and that it would be beneficial to expand the model to multiple courses, include all weeks of online interaction, and relate group development to type and depth of learning.

Instructing, supporting, and facilitating this new online environment is a challenge for educators who are accustomed to interacting with students in a traditional face-to-face environment. With a focus on learning as a cooperative act among participants, the teacher no longer assumes an authoritative delivery position in the instructional process, but rather becomes a partner, coach, mentor, and facilitator in the learning process (Vygotsky, 1986). Students must also move from passive recipients of information to active partners in the knowledge building and problem solving process (Jiang, 1998).

Instead of presenting long lectures, some key points from reading materials can be extracted and turned into provocative, challenging, and open-ended questions about which students can engage in lively online discussions or debate. Virtual seminars or online discussion areas can be created to provide public forums for the instructors and students to present questions for discussions. (Jiang, 1998, p. 52)

Increasing the diversity of tasks will enable students to practice the application of knowledge and create a tool that enables students to work in the BIG (beyond the information given) learning environment (Perkins, 1992). Effective use of CMC capabilities, which engage students in expressing and sharing multiple perspectives in order to formulate new meaning and understanding, and which promote student-student as well as student-instructor interaction, will be an important skill for online instructors in order to create successful online learning environments.

The use of various question types, questioning techniques, and questioning strategies are often found in the literature as a teaching technique that has potential for enhancing collaborative learning and enhancing student involvement in the learning process (Wilén, 1991). The final section of this literature review, examines studies which

involve question types, questioning techniques, and their implications for improving the teaching/learning process.

### Review of Studies on Questioning Techniques

#### Facilitating Interaction: The Use of Questions

Questioning techniques and question types, instructional strategies used to support traditional classroom instruction, are important tools in teaching and learning (Gall and Rhody, 1987). Gall identified several benefits of good questions including the ability to motivate, focus, elicit depth of processing, activate metacognitive processes, and reinforce rote memorization. Gall also showed an increase in higher-order cognitive responses with the increased use of questions that were classified at a higher-cognitive level according to Bloom's taxonomy.

The value of questioning as an instructional technique in the traditional classroom/instructional setting is well documented in the literature on teaching and learning (Wilén, 1991). Questions have been used since Socrates to motivate interest, instruct, and evaluate, and has been endorsed as a method of engaging students in reasoned thought and encouraging students to use higher order thinking processes (Gall, 1970; Sanders, 1966). The belief that questions elicit cognitive activities ranging from simple recall to complex inferences is generally accepted (Janes & Hauer, 1988) and seems to be supported by research (Wilén, 1991). In addition, questions are considered a powerful metacognitive activity because they are one of the primary means through

which individuals can foster their own comprehension (Fishbein, Eckart, Lauver, Van Leeuwen, & Langmeyer, 1990 as cited in Edwards & Westgate, 1996).

### Purpose of Questions

The use of terminology related to questioning (questioning, questioning techniques, questioning strategies) is inconsistent and sometimes confusing in the literature. For the purposes of this discussion, Wilen defined a question as any sentence having either an interrogative form or function. In addition questions are defined as "instructional cues or stimuli that convey the content elements to be learned and the directions for what they (students) are to do and how they are to do it" (Levin and Long, 1981, p. 26.) Questioning techniques as described by Wilen (1991), included the process of planning key questions, phrasing clearly, adapting to ability level, presenting questions logically and sequentially, asking questions at various levels, providing appropriate follow-up, establishing appropriate wait time for responses, encouraging wide participation, and encouraging student formulation of questions.

Ross (1860) suggested that the purpose of questions is to 1) ascertain whether students remember and understand what is taught and 2) to have students apply what they have learned. Other purposes include: to stimulate participation, discussion, review, to involve students in creative thinking, to diagnose ability, assess progress, arouse interest, control behavior, personalize subject matter, and support student contributions. Theory suggests that high-cognitive thought process questions are used for application purposes and low-cognitive thought process questions are used for recall of knowledge (Wilen, 1991). In surveying the research on questioning techniques, Wilen concluded that,

although questions are used to achieve a variety of instructional and managerial purposes in the classroom, the majority of questions used by teachers simply require recall responses from students and rarely require reflection (Gall, 1970). While recall is effective for assessing memorization of factual information, minimal emphasis is placed on encouraging students to think about what they have memorized. He also concluded that, although there is only a 50% congruence between cognitive levels of teacher questions and student responses, there is a positive relationship between questioning techniques and gains in achievement. Throughout the literature, it appears that effective questioning by both teachers and students is important, because asking the right kinds of questions appears to enhance student learning (Foster, 1981; Gall, 1970; Graesser & Person, 1994) and that the use of these techniques fosters student initiative, involvement, and critical thinking (Wilén, 1991).

### Classification of Questions

A variety of classification schemes have been used to categorize questions. Gall (1970) described 11 different classification schemes including those of Adams, Aschner, Bloom, Carner, Clements, Guszak, Pate and Bremer, and Scriber. Most of the schemes are composed of categories classifying questions by the cognitive process that is required to answer the question (Wilén, 1991). Such schemes are useful in that they provide a framework for analyzing the kinds of questions being used in teachers' instructional activities.

Bloom's taxonomy of educational objectives (1956) is the most widely adopted system for classifying cognitive questions in educational research (Brown & Edmondson

in Wragg, 1984). Bloom's categories include knowledge, comprehension, application, analysis, synthesis, and evaluation. Both Sanders (1966) and Hunkins (1972) provided in-depth discussions of classroom questions based on Bloom's taxonomy. Sanders (1966) adapted Bloom's taxonomy to questions by dividing the comprehension category into "translation and interpretation," because of the distinct kinds of thinking involved, and renamed the knowledge category "memory." Hunkins (1989) developed a different scheme (again based on Bloom's taxonomy) in which every question can be analyzed at the five levels of function, dynamics, difficulty, interest, and feasibility. Function defines the question as cognitive or affective. Dynamic defines the question as open or closed in nature. Difficulty level defines the complexity, and interest level defines the concern or curiosity stimulated by the question. Feasibility defines the student's ability to process the question.

Edwards and Bowman (1996) described a category typology proposed by Harvard professor C. Roland Christensen in his seminar on discussion leading. Christensen proposed five categories for discussion techniques including exploratory, challenge or testing, contextual and relational, concluding and conceptualizing. Another system (Hyman, 1982 as cited in Edwards and Bowman, 1996) is described by Riegle to classify interrogative questions:

- Empirical (causal, teleological, functional, non-normative, judgment, descriptive)
- Analytic (linguistic, logical, and mathematical)
- Normative judgment
- Preference

- **Metaphysical**

Guilford's (1956) Structure of the Intellect (SOI) model is also used as a framework for question classification. The three parameters that form the structure of Guilford's theoretical model include the operation of thinking, the content within which the operations are performed, and the products resulting from the performance of these operations on the content. Guilford identifies four types of content; figural, symbolic, semantic, and behavioral.

Gallagher and Aschner (1963) adapted Guilford's model to categories that could be used to produce systematic approaches that identified the cognitive levels of teacher questions in the classroom setting. The Guilford and Aschner question classification scheme is based on the operations of intellect as described by Guilford. Their system has five primary categories and is summarized in Edwards and Bowman (1996):

- **Routine thinking** involves miscellaneous classroom activities. This category includes classroom management, attitudinal dimensions (questions that communicate attitudes, praise or criticism), structuring (prefatory remarks), and humor.
- **Cognitive memory operations** represent the simple reproduction of facts, formulae, or other items remembered through processes such as recognition, rote memory, and selective recall. (To answer this kind of question a student has only to select an appropriate response from memory.)
- **Convergent thinking** represents the analysis and integration of given or remembered data. Students use this kind of thinking when they solve a problem, summarize material, or describe a sequence of steps in a process.

- **Divergent thinking** represents intellectual operations wherein individuals are free to independently generate their own data within a data-poor situation, or to take a new direction or perspective on a given topic. “The student is able to take-off from established facts and see implications or associations not requested by the teacher” (Edwards & Bowman, 1996, p. 11). Divergent thinking may be stimulated by the teacher or by comments of another student in a class discussion.
- **Evaluative thinking** deals with matters of judgment, value, and choice, and is characterized by its judgmental quality. Students may give their opinion or make judgments about value, worth, probability, agreement or disagreement.

A more simple classification was established by Wilen (1991) by combining Gallagher and Aschner's scheme with Bloom's taxonomy. The Wilen scheme identified four kinds of questioning: low-order convergent, high-order convergent, low-order divergent, and high-order divergent. Low-order convergent questions require recall or recognition of information. High-order convergent questions represent the first levels of productive thinking and responses can still be anticipated but require some demonstration of understanding. Low-order divergent questions require students to think critically and analyze or draw conclusions. High-order divergent questions require students to perform original or evaluative thinking and, generally, responses cannot be anticipated.

Brown and Edmondson (in Wragg, 1984) identified several other classification techniques for questions. These classifications include the mode of delivery (threatening, neutral, encouraging); target (who receives the question); and type, and are based on cognitive, affective, or procedural factors. Questions have also been classified by

categories based on the reasons why questions are asked, i.e. explanation, clarification, and diversion (Crouch, 1998). One of the simplest and more common classification systems is open-closed and recall-thought (Brown & Edmondson in Wragg, 1984). Open questions are described as those permitting a wide range of responses including the expression of feelings. Closed questions, on the other hand, have one "best" answer. A pseudo-question is defined as one that appears open, but is used when the teacher is seeking one particular reply. Recall questions are the most common type of question asked by teachers and require students to recall existing information; thought questions require students to use existing information to create new information (Brown & Edmondson in Wragg, 1984).

#### Problems with Classifying Questions

Brown and Edmondson (in Wragg, 1984) described several reasons for caution when dealing with classification of questions. They pointed out that context is a problem for classifying questions and that the same question may be one type of question in one context and another type of question in a different context; and it is likely that modes of questions will vary between subjects. In addition, question types may vary according to class ability. When classifying questions across contexts, they observed that one can make legitimate observations but cannot legitimately make generalizations across contexts.

In spite of these complexities, and the fact that systems of question classification will inevitably be modified by the context in which they are used, Brown and Edmondson concluded that questioning is so important to the learning process that researchers must

continue to strive to understand its use. The issue of confounding variables of context and content is certainly one of the reasons for inconsistencies in the literature regarding questioning, however, Brown and Edmondson pointed out that this is one of the central problems in classroom research and is not unique to the issue of question classification.

### Teacher's Use of Questions

Extensive research on questioning in the classroom has been conducted at the precollege level and described by Gliessman (1985, p.1) as "among the two or three most studied phenomena in teaching". The smaller body of questioning literature at the college level indicates that the results are somewhat similar and that the precollege research provides higher education faculty with insights regarding their students' experiences and reactions to questioning.

The questioning research repeatedly demonstrates that teachers at all school levels (K-16) and subject areas typically ask low-cognitive questions that require knowledge or memory level thinking, emphasizing facts, not higher level thinking (Davis, Morris, Rogers, & Tinsley, 1969; Gall, 1970; Clegg, 1971; Barnes, 1983; Wilen, 1991). Gall (1970) estimated that 60% of questions posed by teachers require memorization, 20% require thinking, and the remaining 20% are procedural and noted that it is "reasonable to conclude that in a half-century there has been no essential change in the types of questions which teachers emphasize in the classroom" (p. 713). This predominant use of low-cognitive level questioning also applies to written questions, texts, and tests (Gall, 1970).

Barnes (1983) conducted an extensive study of teacher questioning at four undergraduate institutions utilizing the Gallagher-Aschner question classification scheme and found results that confirmed the previous research. The overwhelming percentage of all questions teachers asked, regardless of institution type, student level, or discipline, were on the lowest cognitive level. The study also found that a very small portion of most college classes was spent in questioning and that the questioning level was not significantly different between beginning and advanced level courses. The level of questioning varied only at the lowest cognitive level with science/math/engineering professors asking more low-level questions than did humanities/social science professors.

In his informal higher education classroom observations, Gliessman (1985) noted that even when interpretative questions were posed, it was clear that a literal correct response was really sought by the instructor. Many teachers that he observed appeared to ask numerous questions, prefer short answers, and set a fast pace of questioning. He also noticed that college students tended to "search out" the instructor for correct answers, seemed to have difficulty constructing complex answers, and were reticent about responding to any question.

Edwards and Bowman (1996) conducted research that indicated that the use of questions in the classroom may be changing. Edwards and Bowman (1996) studied questions asked by teachers and students in a graduate-level occupational therapy course at Western Michigan University. The results showed only 45% of the professor's questions were routine and cognitive, with the remaining questions at the higher cognitive levels of convergent, divergent, and evaluative. Results also showed that

students asked almost as many questions as the professor did and that many student questions were identified at higher cognitive levels as well, supporting previous research indicating that increased teacher use of questions positively influences student questioning. Edwards and Bowman also looked at the influence of instructional format (lecture, media presentation, exams) on question type and concluded that questions may be influenced by the types of instructional format used to deliver information in the classroom. Edwards and Bowman (1996) suggested that when appropriate pedagogical strategies are used, students will be willing to ask a greater number of questions, however, "the teacher's traditional role as sole authority may need to be modified for this kind of question asking to occur" (p. 21).

Although many assume that there is a direct and positive relationship between the cognitive levels of questions and student-thought levels, the research findings are mixed. Taba, Levine, and Elzey (1964) found that a teaching strategy with extensive questioning was the single greatest influence on cognitive performance and that "the nature of the questions has a singular impact on the progression of thought in the class" (Taba et al., 1964, p. 177). Gallagher and Aschner (1963) found that a 5% increase in divergent-level questioning initiated a 40% increase in divergent responses from students and determined that the teacher controls the level of thought in the classroom. Foster (1981) conducted a study using third-year medical student clinical discussion groups and found that the cognitive level of the teachers' questions had a significant, positive correlation with the cognitive level of the students' responses. The amount of higher-cognitive level discussion in the groups varied according to the cognitive level of the teachers' questions.

Foster noted, however, that teachers asking the greater number of higher-level questions, also tended to accompany their questions with probing statements or questions that allowed students to elaborate on their responses.

On the other hand, Konya (1972) found that students responded more often at higher levels of thinking when teachers asked an equal amount of high-, and low-cognitive questions. Mills, Rice, Berlinger and Rousseau (1980) found only a 50% relationship between the cognitive level of teacher questions and student response and concluded that there is no correlation between types of questions and student responses. Dillon (1988) found a similar lack of correlation between student responses and the cognitive level of teacher questions.

The research also appears to be inconclusive regarding the relationship of cognitive levels of questions and gains in achievement (Wilén, 1991). Gall and Rhody (1987) noted that this lack of evidence regarding both cognitive levels of questions and responses, and gains in achievement, may be due to lack of consistency in the various question-classification schemes. He concluded that teachers should use both low-, and high-cognitive questions. "It is difficult to imagine how students will learn to think unless they have repeated opportunities to respond to higher-level questions." (Gall and Rhody, 1987, p. 42)

#### Value of Questioning Techniques in the Traditional Classroom

Numerous studies have been conducted on the value of questioning techniques in a teaching/learning situation (Wilén, 1991). Stevens (1912) conducted the first major

systematic research on questioning and concluded that if instruction was to improve, teachers must develop questions that stimulate reflective thinking. Other studies, sparked by the Sputnik era of curriculum reform, established that the ability to develop higher cognitive thought processes and utilize an inquiry approach to teaching, required teachers to have the ability to stimulate critical thinking skills through effective questioning behaviors (Wilén, 1991).

Additional research is needed to determine how questions can be used to encourage students to assume more responsibility for classroom discussion, and how teachers and students can acquire the skills appropriate for discussion interaction patterns (Cyrus, 1997; Jiang, 1998). Rowe (1974, 1986, 1987) found that training teachers to increase the amount of wait-time between asking the question and obtaining an answer resulted in increased student interaction, increased responses at a higher-level of thought, decreased failure to respond, and increased frequency of student questions. There is also research to indicate that experienced teachers ask more questions, and that the frequency of questions and student learning is positively related (Wilén, 1991). The use of statements also appears to effect student participation. Dillon (1988) found that the use of statements and wait-time (in conjunction with questions) resulted in more student participation, talking, student-student interaction, and student questions. Wood & Wood (1988) also found that teacher statements resulted in longer student responses and greater student initiatives than did questioning alone.

The role of questions in discussion also appears in the literature. Dillon (as cited in Wilén, 1991) found that researchers labeled any teacher-student interaction as

discussion, although the interaction pattern between student and teacher and between students and students is more varied in discussion than in a traditional question-answer recitation. Research shows that the role of questioning and non-questioning techniques such as statements, academic questions, wait-time, student questions, response receptivity, silences, acknowledgement of student response, and probing, increase student participation in discussion. (Wilén, 1991) The successful discussion appears to be based more on student behaviors and less on teacher behaviors, and the successful discussion depends on the teacher's willingness to reduce control and encourage student initiative and involvement. The research also concludes that recitation is the primary form of interaction in the classroom and that discussion is used infrequently (Wilén, 1991). Wilén and White (1989) concluded that more research is needed on how questions can be used with non-question techniques to stimulate student participation and thinking in the broader context of classroom interaction.

#### Questioning Techniques And Faculty Development

Teachers can be trained to improve questioning techniques and practices (Wilén, 1991). Wilén noted that the questions that teachers ask and their questioning technique imply their individual philosophy of teaching. Several studies have shown that teachers can be effectively trained to raise the cognitive emphasis of their questions (Wilén, 1991) and that instructional improvement techniques such as peer observation, instructor modeling, microteaching, minicourses, and coaching have all shown improvement in questioning practices (Wilén, 1991).

The QUILT Project (Questioning and Understanding to Improve Learning and Thinking) (Office of Educational Research and Improvement, 1994) attempted to improve teacher use of effective questioning techniques. Teachers in the program were encouraged to think about the what, how and why of questions and to compare their own behavior with best practices. Based on the present day reform goal of moving students beyond short answers to lengthier and more complex responses, the QUILT Project attempted to support this goal through improved questioning techniques. Teachers were encouraged to reduce the total number of questions asked, increase the number of questions posed at higher-cognitive levels, and to increase their use of wait-time in classroom discourse. The project showed that students became more accountable for their own learning in QUILT classrooms where teachers used wait-time, posed questions before designating respondents, redirected questions, and did not habitually repeat student answers. QUILT classrooms also significantly increased student responses at higher- cognitive levels. Teachers, however, showed significant increases in their knowledge of effective questioning practices, but little positive change in the use of these practices.

Luallen and Leonard (1991) implemented a teacher support program to encourage secondary science teachers to change their traditional cycle of lecture, note taking, review, and test. Teachers most often described their reason for using this model as "this is the way that I was taught during my formal education, and I obviously learned well" (Luallen and Leonard, 1991, p. 2). Bettencourt and Gallagher (1990) noted that teachers see themselves as presenters of scientific information and that the students job is to learn

it. Luallen and Leonard (1991) reported that teacher implementation of questioning techniques, such as setting a non-threatening tone, valuing any response (even wrong), allowing and encouraging students to share information, and avoiding the quick answer, resulted in multiple improvements. Students became more actively engaged in knowledge construction, less passive, more involved in interaction and collaboration with other students, and improved the quality and quantity of their writing. Luallen concluded that the use of questioning techniques to encourage students to discuss problems in more detail gave valuable insight to diagnosing their real understanding of scientific concepts.

Kurtz (1994) noted that dramatic changes in student characteristics and demographics, increasing knowledge about teaching and learning, and the rapid rate of knowledge acquisition requires college faculty to adopt new strategies for teaching. Observing that many faculty are not aware of specific teaching and learning behaviors that occur, Kurtz proposed that increasing awareness of teaching and learning practices in the classroom can help professors recognize needed changes. The study involved peer groups of faculty observing one another's teaching, identifying specific behaviors, and setting goals for improving behaviors. As a result, faculty indicated that they were able to identify specific behaviors in their teaching that resulted in more classroom participation by all students. In specific, faculty described that they increased being explicit about learning outcomes, increased clearly delineating instructional goals, and increased their use of classroom examples that linked students' preexisting knowledge and beliefs to the course content. They also observed that their questioning techniques

were often combative and debate-centered, and that the depth of discussion increased when they were more patient and less threatening. Luallen concluded that faculty behavior can be altered by enlisting the assistance of peers; however, this requires that peers have training in teaching strategies and intervention, and that they are able to establish an adequate level of collegial trust.

### Questioning Techniques in Distance Learning Environments

Little research was found regarding the use of questioning techniques in a distance-learning context. Muscella and DiMaura (1995) analyzed electronic conversations among science teachers and found that focused discussion threads established long term discussions among participants as compared to unfocused discussion threads. Although questions were often used by instructors to solicit interaction in a computer mediated conferencing environment, seasoned online course participants indicated that questions may be used inappropriately in online instruction by instructors who evaluated students based on quantity rather than content of their responses (NTEN, 1998). Fenwick and McMillan (1992) identified ways that questions are used in distance education and indicated that further research is necessary before generalizing existing work on questioning techniques as a teaching/learning tool in the distance learning environment. Self-assessment questions and questions in assignments and examinations were cited as neglected areas of research that hold promise for the distance learning context.

In a review of the literature and analysis of CMC interaction, Hegngi (1998) identified several studies demonstrating that well-designed Web-based and CMC instruction promotes learning. (Fetterman, 1996; David, 1992 as cited in Hegngi, 1998). Uchida concluded that well designed instructional activities on the WWW facilitate critical thinking, problem solving, writing and group interaction or collaborative skills (as cited in Hegngi, 1998). Clark observed that media technology is simply a medium and that learning improvements only result from systematically-designed lessons (as cited in Hegngi, 1998).

Berge (1997b) hypothesized that since online teaching is a more learner-centered environment, those who choose to teach using interactive technologies have chosen to do so as a reflection of their own learner-centered approach to teaching. He surveyed people who have taught online postsecondary courses and found a common thread of low structure and high dialogue. Results showed that 75% of the respondents placed emphasis on students doing activities themselves, as opposed to detailed assignment sheets, syllabi, notes, or textbooks. Most were inclined to use student-focused methods with little direct instruction. The ability to guide learning by asking the "right questions" was viewed as being more important than giving students the right answer. Instructors used discussion to guide the future direction of the instruction. Berge concluded, however, that just because instructors used student-focused methods did not mean that they used them effectively or efficiently. He also agreed with Moore (as cited in Berge, 1997b) that more research is needed to determine exactly what is happening during online activities with regard to design and implementation of various teaching methods.

The literature regarding instructor use of questions in online instruction is very limited, although this topic is often cited as worthy of further research. Crouch (1998) examined variables related to student question forming in distance learning courses. In a study surveying 127 students in distance learning and traditional courses, Crouch (1998) found that there was significant correlation between parasocial interaction (perceived relationship with a media persona) and question forming in the distance classroom. There was also a significantly higher relationship between students' perceived learning and question forming in the distance classrooms than in the traditional classroom. Question forming, however, was observed only for students (not instructors) and was quantified only by student reports of their own level of question forming throughout the course.

Jiang (1998) conducted both a quantitative analysis on 109 surveys completed by students in courses taught entirely online, as well as a qualitative analysis of three online courses, in order to analyze factors influencing students' perceptions of online learning. Results of the quantitative analysis indicated that two instructional variables, a grade for discussion and requirements for discussion were statistically and positively related to students' perceived learning. In addition, the grade for discussion was statistically and positively related to students' perceived degree of interaction with fellow students. In the qualitative analysis Jiang noted several findings:

1. Students' perceived learning was related to an instructor's participation in the course;
2. High-perception of learning courses placed more instructional emphasis on online discussion;

3. Questions in the high-perception of learning courses sought a broad scope of answers or multiple perspectives on a topic, were open-ended, and used controversial issues;
4. The structure of questions in the high-perception of learning courses was carefully and elaborately designed;
5. Questions in the high-perception of learning courses focused more on the students and the world around them as the center for discussion.

Jiang (1998) concluded that there is a possible relationship between the structure and nature of instructor questions and patterns of student response in online courses.

It seemed that the way the discussion questions were structured was reflected in the way students responded, and finally might also be reflected in how students perceived their learning experiences in the course. It would contribute to educational research...if future research could test the effect of the design of questions on patterns of students' responses.  
(p. 235)

Paloff & Pratt (1999) devoted considerable discussion to the use of questions in their manual for online instruction. Although this book is based on personal observation and experience, and does not involve any empirical research, the authors made a convincing argument for the importance of questions in facilitating collaborative learning and online dialogue. Paloff and Pratt argued that skilled discussion "involves a dynamic balance between advocacy of views and inquiry about the associated references" (p. 119), and requires that the online instructor be able to facilitate the dialogue without dominating it. They proposed that instructors learn and develop the art of asking "expansive questions" (p. 119) that provide a jumping off point for discussion, that promote a thorough exploration of a topic and the development of critical thinking skills. By modeling this form of questioning, students will also learn to ask them of each other.

The authors proposed that the effectiveness of a question can be measured by the level of discussion and participation that it creates. Poor or minimal response indicates that the question has not done its job of stimulating a level of thinking that excites learners and compels them to respond (Palloff and Pratt, 1999).

Although this study was focused on the online (CMC) environment, there are several studies in the literature related to teaching techniques in instructional television (ITV), or interactive video delivery, that should be mentioned. Kochery (1997) surveyed current practitioners using ITV at the University of Minnesota. Faculty training needs identified in the survey most frequently included strategies that promote interaction and developing TV lectures. Kochery concluded that distance education requires more attention to strategies that promote interaction such as questioning techniques, discussion, and active learning. He suggested that students may be isolated and lack social support in a distance learning environment. He noted that most strategies used for increasing interaction are still dependent on a teacher-centered design and delivery of instruction. Bland (1992) surveyed students at Memphis State University participating in two first-time ITV courses offered by the College of Education. Students complained that questioning in the class was disconcerting, because it took too much time to focus the camera on the person speaking, and they were unable to see who was talking. When asked if the instructor should place less emphasis on the use of questions, 48% of the students disagreed. The majority felt that questions should be directed to the whole class and 50% indicated that they were shy about asking questions on camera. Eighty-one percent of the class favored having more small-group discussion. Forty-six percent of the

students said that the instructor spent too much time with the equipment and 96% agreed that the instructors needed intensive training on using the equipment and on strategies that work in the distance-learning classroom. Bland concluded that the most effective instructional strategy for ITV is a well-designed lecture, supported by visual aids. Interactive TV should not imply that interactivity is required in the teaching/learning process, but as a capability of the technology that can be used if, and when, it benefits the instruction.

Johnstone (Western Coop for Educational Telecommunications, 1994) analyzed the seven innovative degree programs funded by the Annenberg Pathways for a New Degree project. In this analysis, students and faculty rated all technologies (email, CMC, real-time chats, audio-conferencing) as "equal to" or "better than" their experience in the traditional classroom. The only two technologies receiving less than an equal or better rating were ITV and live video with audio-talk back. Johnstone concluded that these are the two technologies that most allow instructors to deliver instruction in the same manner as in the traditional classroom, resulting in less interaction, less spontaneity, and greater effort to obtain student feedback. The resulting student frustration with interaction in the course was not due to the technology, but to the teaching techniques utilized by the instructor.

### Summary

This literature review examined three areas of research that play an important role in attempting to understand how questioning techniques might be employed to facilitate online dialogue that engages students in the learning process. The three areas reviewed include online learning, constructivist learning theory, and questioning techniques in both the traditional and distance-learning environment.

Although still relatively small, the use of computer-mediated-conferencing in online instruction is probably one of the better-researched areas of distance learning. Advantages to CMC use in instruction are repeatedly described in the literature and include anytime/anywhere (asynchronous) capabilities; students' ability to reflect on their own responses and fellow students' responses; mentoring models of instruction; promotion of interdisciplinary problem solving; and ability to foster multiple perspective approaches to teaching and learning. Several weaknesses cited regarding the literature revolve around the fact that most of the studies have been conducted using courses in which CMC supplements, rather than replaces, traditional classroom instruction, and that a majority of the studies are based on anecdotal, self-reported data regarding student perception of satisfaction.

The literature review on constructivist learning theory indicates that constructivist learning theories are becoming widely accepted in many fields of education, including the application of technology to teaching and learning (Kanuka and Anderson, 1998). Online learning is currently most often associated with social constructivism in which knowledge is thought to be generated through social interaction. Constructivists believe

that individuals construct knowledge based on what they already know, and that learning is an active, rather than passive, process. The literature debates the role of the instructor in constructivist learning theory; however, it repeatedly supports the value of dialogue between students and between student and instructor in both traditional and online instruction. Emerging research indicates that the online instructional environment is an ideal vehicle for establishing collaborative learning and supporting the social construction of meaning.

Review of the literature reveals substantial documentation regarding the use of questioning techniques in the traditional classroom setting. Research attempting to find a positive relationship between specific types of questioning techniques and improved student learning has had inconclusive results. There is evidence, however, that specific questioning techniques and use of specific question types can be highly influential in engaging students in the learning process and establishing a learning environment that is conducive to knowledge construction at the higher-cognitive levels.

Little was found in the literature regarding the use of questioning techniques in online, CMC instruction, however several studies were found indicating that research regarding the use of questions in online instruction is warranted. No studies were found that examined the types of questions used by instructors in online instruction and no studies were found that addressed the use of questions as an instructional strategy to promote online discussion and encourage student-student interaction, both of which have been shown to facilitate construction of knowledge and higher-cognitive learning in the

traditional classroom. This study was conducted as an initial effort to contribute to this missing piece in the literature on online education.

## CHAPTER THREE

### METHODOLOGY

#### Introduction

The current literature provides a great deal of information about the value of various question types and questioning techniques used by instructors in the traditional classroom setting. There is also a body of literature, although relatively new, regarding the value of student-student and student-instructor interaction in online instruction. Little information, however, was found regarding the use of questions and questioning techniques in online instruction in general, and as an instructional technique to promote online dialogue that facilitates a constructive learning environment in specific. The information that exists is primarily descriptive, collected from observation, and student and instructor perceptions (self-reports) regarding online interaction in an instructional setting. In addition, most of the literature found regarding instruction in an online environment reflects research conducted on single courses and courses in which online interaction was used to supplement or complement traditional classroom instruction.

This study used a combination of established research tools to examine the relationship between types of instructor-initiated questions and the resulting student-student and student-instructor interactions in graduate science courses delivered entirely online, using computer mediated-conferencing for instructor-student interaction. The classification of questions according to the Wilen hybrid system of question classification

adds to the existing knowledge base regarding type of questions used by instructors, and establishes initial efforts to expand this understanding to the online teaching/learning environment. The use of discussion diagrams, an adaptation of sociograms--a social network analysis tool frequently used to study traditional classrooms (Bickel, 1998), provided an illustrative and quantitative measure for observing student-student and student-instructor response patterns in a computer-mediated-conference interaction.

### Research Design

#### Population to be Studied

The population for this study was made up of instructor-initiated questions in graduate science courses developed and delivered entirely online as part of the National Teachers Enhancement Network (NTEN) at Montana State University-Bozeman. NTEN was originally funded by the National Science Foundation in 1993 and has developed and delivered over 30 individual online graduate credit science courses over the past seven years. Students in the NTEN courses consisted primarily of science teachers employed in middle schools and high schools nationally and internationally. The course instructors were primarily faculty in the physical and biological sciences at MSU-Bozeman. Several course instructors have faculty appointments in the sciences at other institutions of higher education.

The NTEN program has two main goals. The first goal is to offer high-quality graduate courses in the sciences that are developed and taught by active research scientists, with support from in-service secondary science teachers and science educators. The courses are designed to increase teachers' understanding of the science content and

to model active, hands-on, and collaborative learning that is important in the secondary classroom (Smith, 1999). The program simultaneously promotes communication between scientists and K-12 teachers dedicated to science education (Wheeler, 1992).

The second goal of the NTEN project is to deliver these courses in a distributed distance-learning format in order to increase the number of teachers who have access to high-quality professional development opportunities. The majority of NSF-sponsored teacher enhancement programs require teachers to travel to a specific location (usually in the summer) in order to participate. Unfortunately, this model serves only those teachers who live close to the professional development providers or those who can afford the time and expense of being away from home, family, and employment. The NTEN program is designed to reach teachers where they live and work in order to increase access and equity for participation in professional development programs. Teachers can participate in NTEN courses without leaving home or family, summer employment, and other personal and professional commitments (Wheeler, 1992).

NTEN Students Students in the NTEN courses were 52% male and 48% female. They were employed primarily as science teachers in secondary rural and urban schools and tend to be active participants in professional development programs. Most NTEN participants fit many of the criteria identified for students most likely to be successful in a distance-learning environment. They were above traditional college age, risk-takers, highly motivated learners, and independent in life-style as well as learning-style (Smith, 1996).

NTEN students tended to be motivated and took responsibility for their own learning for several reasons: 1) teachers were rewarded for successful completion of academic courses by increase in salary, 2) many NTEN students were completing these courses as requirements for completion of a graduate degree program, 3) HRI evaluation data showed that the majority of these students are regular participants in professional development programs, and 4) NTEN students reported that their number one reason for taking the course was to improve their knowledge of the course content (Smith, 1997).

NTEN evaluations consistently showed high marks for students' overall satisfaction with the courses, increased knowledge content, and indication that online interactions with both participants and instructor helped them better understand the course material (Smith, 1996). NTEN has been able to establish and maintain an electronic instruction environment with consistent student perceptions that interactions with their classmates help them understand the course material, which is not the norm in traditional classroom instruction. (Smith, 1996)

NTEN Faculty The majority of NTEN faculty members have doctorate degrees in their fields and currently hold tenure-track faculty positions at post secondary institutions. Many of them are senior faculty who are tenured and have significant research programs and careers. NTEN faculty range from little or no experience with secondary teaching and science education, to being actively involved in a number of professional development and science education programs for K-12 teachers. Several NTEN faculty have developed and taught more than one NTEN course, and the majority of the faculty have now taught NTEN courses multiple times. All NTEN faculty were

provided with financial support by the NSF grant for course development time and effort. They were also provided with technical support, distance learning seminars and workshops, and the opportunity to work with other NTEN faculty to share ideas, observe course design and teaching, and critique ideas (Smith, 1996).

### Course Selection

The instructor-initiated questions and discussions to be analyzed were drawn from a sample of NTEN courses. The entire pool of NTEN courses, selection criteria, and the final sample of courses are listed in Appendix A. NTEN course instructors and participants were informed prior to beginning the course that the program was funded by NSF and that course observations and data might be utilized for research purposes. All course identification factors were removed, and participant and instructor names remain confidential.

This study included all NTEN courses that met the following criteria:

1. Courses utilized the FirstClass™ CMC software for course interaction;
2. The course was not a repeated offering of a previously selected course;
3. The number of participants fell within the NTEN average class size range of twelve to twenty;
4. The instructor required students to participate in some form of online interaction as part of their overall course grade;
5. Faculty and students were informed that the NTEN courses were part of an NSF-funded program in which the content might be observed and utilized for research purposes; and

6. The course content was in the biological and physical sciences.

Because of changes in software over the years, the flexibility afforded to faculty in course requirements and design, and courses with low enrollments, it was not possible to investigate all of the NTEN courses. It was anticipated that this selection process would result in 10-12 NTEN courses that met all of the criteria; or approximately 33% of all NTEN courses that have been developed. Controlling the course selection process, both for class size and instructor-required online interaction, was important in order to select a representative course sample for this study. Several NTEN course instructors did not clearly specify that online interaction was required. In the previous literature review, it was identified that lack of clear expectations and instructor-emphasis on online interaction has been shown to negatively influence student online interaction and participation (Jiang, 1998; Palloff & Pratt, 1999; Anderson & Kanuka, 1997). Appendix A identifies all possible NTEN courses and the courses selected according to the criteria defined in the study.

#### Data Collection

Following course selection, electronic transcripts or recordings from the selected NTEN courses were reviewed to identify the questions that instructors asked students, and the dialogue that resulted from these questions. The use of computer-mediated conferencing in online instruction provides the researcher the advantage of maintaining a transcribed record of all course interactions (Williams, Rice and Rogers, 1988). In the NTEN project the host computer maintained a complete textual and graphical database of all course interaction, referred to as a course transcript. The NTEN project has

maintained complete transcripts of every NTEN course offered. The transcripts consist of all messages and responses between faculty and students, and students and students, that are posted to the class "public" discussion areas. Private messages between faculty and student or student and student are not maintained for privacy reasons. Public discussion areas in the course are only accessible to the professor, students, technical support staff, and NTEN staff and evaluators. The NTEN courses are password protected and not available to the general public.

#### Selection of Instructor-Initiated Questions

Transcripts for each selected course are maintained on a server at Montana State University-Bozeman and were obtained from the NTEN technical staff. In order to eliminate instructor-initiated questions related to circumstances of course start-up, including procedural clarifications and technical support, this initial intent of this study was to identify all instructor-initiated questions asked after the first two weeks of the beginning of the course. Since most NTEN courses were 12-15 weeks in length, transcript analysis would therefore be conducted on approximately 10-13 weeks of each course. Transcripts were reviewed in order to identify all instructor-initiated questions in each course and to delineate the discussion that follows each question.

Discussions for this purpose are defined as a single discussion thread that focuses primarily on the instructor-initiated question. The FirstClass<sup>TM</sup> computer-mediated-conferencing software organizes the online interaction according to discussion threads. Responses to an instructor's question are grouped together in the electronic transcript so that all responses and follow-up questions related to a particular question can be defined.

It is this discussion thread that was used in the construction of discussion diagrams in order to map all of the dialogue related to a specific instructor-initiated question. The discussion "thread" command function of the FirstClass™ software (used for online course interaction in the NTEN courses) was used to identify the discussion related to each question. Threads were identified by using the software to conduct a search for all responses linked to the original "subject" heading of a message in which a question was posted by the instructor. A sample discussion "thread" search result is included in Appendix B. In some cases, an instructor would specify that all responses to a given question should be posted to a specific conference area or folder. In these cases, all responses were used from the area specified by the instructor in order to delineate the discussion responses for that particular diagram.

Past research results show that students should progress to advanced levels of thought as their content knowledge increases; and there is some indication that group development occurs in a linear fashion over time in courses delivered using CMC online (McDonald, 1998). Upon identification of instructor-initiated questions and discussion threads, each question and thread was coded in order to determine whether it occurred during the first-third, middle-third, or final third of the course. This coding enabled the data analysis to include comparisons between the cognitive levels of questions and interaction indices that occurred at various time periods throughout the course.

### Question Classification

Instructor initiated questions, identified from course transcripts, were classified based on the Wilen (1988) hybrid question classification system which combines the

Gallagher/Aschner conceptualization with Bloom's taxonomy categories. Wilen first divided questions into two categories of convergent and divergent, based on a hierarchy of intent to produce narrow and broad student thinking. These two categories were then further divided into low and high levels. Wilen described convergent questions as those designed to determine basic knowledge, skills, and understandings in order to prepare students to apply information or material they have learned. Divergent questions require students to engage in critical thinking as they process information (Wilen, 1991). The Wilen classification system includes the following four levels:

- **Level I-Low Order Convergent:** These are questions requiring students to engage in reproductive thinking with the intent to have students recall or recognize information. Emphasis is on memorization and observation, and students' responses can be easily anticipated. (Corresponds to Bloom's Knowledge level)
- **Level II-High Order Convergent:** Questions in this category require students to engage in the first levels of productive thinking. The intent is to have students go beyond the level of recall and to demonstrate understanding of information by mentally organizing material that has been previously learned. Although more thinking is involved, responses can still be anticipated at this level. (Corresponds to Bloom's Comprehension and Application levels)
- **Level III-Low Order Divergent:** This category includes questions that require students to think critically about information. The teacher's intention is to have students analyze information to discover reasons or causes, draw conclusions or

generalizations, or to support opinions. Higher-level productive thinking is involved and responses may not be anticipated. (Corresponds to Bloom's Analysis level)

- **Level IV-High Order Divergent:** This category requires students to perform original and evaluative thinking. Making predictions, solving lifelike problems, producing original communications, or judging ideas, information, actions, and aesthetic expressions based on internal or external criteria are all outcomes of this category. This level represents the highest level of productive thinking and students' responses, generally, cannot be anticipated. It also corresponds to Bloom's Taxonomy levels of synthesis and evaluation (Wilén, 1991; Kindsvatter, 1988, pp. 113-14; Wilén, 1985, pp 4-6).

The Wilén hybrid model was selected for this study for several reasons. The model is a 1988 adaptation of the earlier Bloom (1956) and Gallagher/Aschner (1963) models, and appears in the more recent literature on question types. It incorporates Gallagher and Aschner's emphasis on productive thinking and supports the notion of constructive learning in which the individual draws on past and present knowledge to construct new facts, ideas, and conclusions (Gallagher and Aschner, 1963). In addition this model addresses the issues of reliability related to question classification by; 1) providing detailed examples and a descriptive checklist available for verifying classification of questions; 2) corresponding to specific levels of Bloom's taxonomy, which can be tied to established question cues or verb examples for reliability in classifying questions in each category (University of Victoria, 1996; WestEd, 1999), and 3) offering a simplified system with fewer categories, which reduces the opportunity for errors in reliability.

A checklist (Table 1), using Wilen's levels of questions and corresponding Bloom's taxonomy and key verbs or question cues was constructed in order to assign questions to each of the four levels and to tabulate the total number of questions in each category.

Table 1. Question Cues for Wilen Question Levels Based on Blooms Taxonomy

Wilen Question Level	Blooms Taxonomy	Question Cues (Reference)
I	Knowledge	List, Define, Tell, Identify, Label, Name, Quote, Tabulate
II	Comprehension Application	Summarize, Describe, Interpret, Predict, Determine, Associate, Extend, Apply, Demonstrate, Share, Illustrate, Show, Solve, Discover, What, Why
III	Analysis	Discuss, Compare, Contrast, Analyze, Separate, Connect, Classify, How Does, Infer
IV	Synthesis Evaluation	Explain, Evaluate, Argue, Assess, Rank, Modify, Substitute, Plan, Create, Design, Invent, Compose, Formulate, Rewrite, What If, Convince, Conclude, Support, Select, Recommend

### Discussion Diagrams

Once questions were identified and classified for each course, the discussion thread connected to each question was used as the basis for constructing a discussion diagram based on the student-instructor response patterns to each question. Discussion "threads" are determined by the FirstClass™ software, linking all electronic messages that are posted as a response to a specific item. This feature allows for the creation of electronic "discussions" that are focused on a particular topic. The topic of each

discussion thread used in this study was an instructor-initiated question. Discussion diagrams were drawn for each question and discussion thread, and used to calculate interaction indices as well as provide a visual representation of the response patterns that occurred following each question.

The discussion diagram concept was developed by HRI for “ illustrating and quantifying in concrete terms the interactive nature of online discussions.” (Bickel, 1998). Bickel described discussion diagrams—a social network analysis tool frequently used to study traditional classrooms—as a model based on the field of sociometry and the use of sociograms. Current HRI evaluation of NTEN online interaction is based primarily on participants perceptions and qualitative assessment of online discussions. HRI developed this discussion model diagram in order to provide a more visual and quantitative analysis of the types of online discussion that was observed in the NTEN courses. (Bickel, 1998)

Sociometry is concerned with the social interactions among any group of people. The data collection is geared toward obtaining information about the interaction or lack of interaction among the members of a group (Sellitz, Wrightsman, & Cook, 1976). The concept of sociometrics was pioneered by Jacob Moreno in an effort to create an experimental methodology applicable to all social sciences that would blend research, therapy and theory in order to establish a systematic understanding of the principles governing social conduct (Moreno, 1960). Northway (1952) defined a sociometric test as a means for determining the degree to which individuals are accepted in a group, for

discovering the relationships that exist among these individuals, and for disclosing the structure of the group itself.

Sociometrics has been adapted for group analysis in many social sciences and appears frequently in the analysis of classroom behavior and interaction (Semple, 1982). In a review of the literature of sociometry, Semple (1982) described sociometrics as one of the most interesting and rewarding techniques for teachers. The review includes studies in which sociometrics have been used to further our understanding of student grouping and related academic climates, skills needed for cooperative working conditions, friendship relations, gender issues, socialization, and learning styles. Moreno (1960) noted that sociometric methods of assessing social relations have been shown to possess ample reliability and validity for extended use in systematic research.

Various diagramming techniques called sociograms have been developed as tools to depict relationships and to identify scoring and graphic methods in sociometric testing (Moreno, 1960). The target diagram (shaped like a bullseye target), provides a picturesque means of symbolizing the structure of, and relationships in, a group. However, Moreno (1960) cautions that this is an abstract symbol, and that the notion that the center of the target is the most desirable outcome may be misleading in many cases. Interaction diagrams, similar to those used in this study, have been used extensively with observational laboratory research in order to map the interaction between individuals in a group without indicating that certain interaction results are better than others (Moreno, 1960). Researchers have developed simple ratios or sociometric indices that are employed to evaluate the relative position of an individual or subgroups within a

population (Nehnevajsa, in Moreno, 1960). Over the past 30 years, many adaptations and combinations of sociogram techniques have been used to depict and analyze sociometric data (Semple, 1982; Robson, 1993).

### Constructing The Discussion Diagram

Discussion diagrams for this study employ both the use of interaction diagrams and sociometric indices. Construction of the diagrams consisted of two steps. The first step involved building a model that illustrates the interactions between all the participants in a single discussion thread, thereby allowing observers to quickly visualize the nature of student and instructor involvement in a single discussion. The second step required calculating indices from the model that quantify the interaction taking place between individual students and instructor, and that represent the extent to which the interactive potential of the discussion is realized. The majority of instructor-initiated questions in this study were posed to the entire course population and interaction indices were calculated based on the total number of students in the course. In some instances, students were divided into smaller discussion groups for the purpose of responding to instructor-initiated questions. In this case, the size of the discussion group was determined and this number was used as the total student count in the calculation of interaction indices in small group discussions.

The following discussion diagram model and examples are provided by Bickel (1998). Constructing a discussion diagram model first consists of identifying "nodes" representing discussion participants (in this case students and instructors) and diagramming the connections that represent exchanges between nodes. A simple

discussion diagram is illustrated in Figure 1 (Bickel 1999), showing nodes as filled circles and connections as arrows.

Figure 1. Sample of a Discussion Diagram.

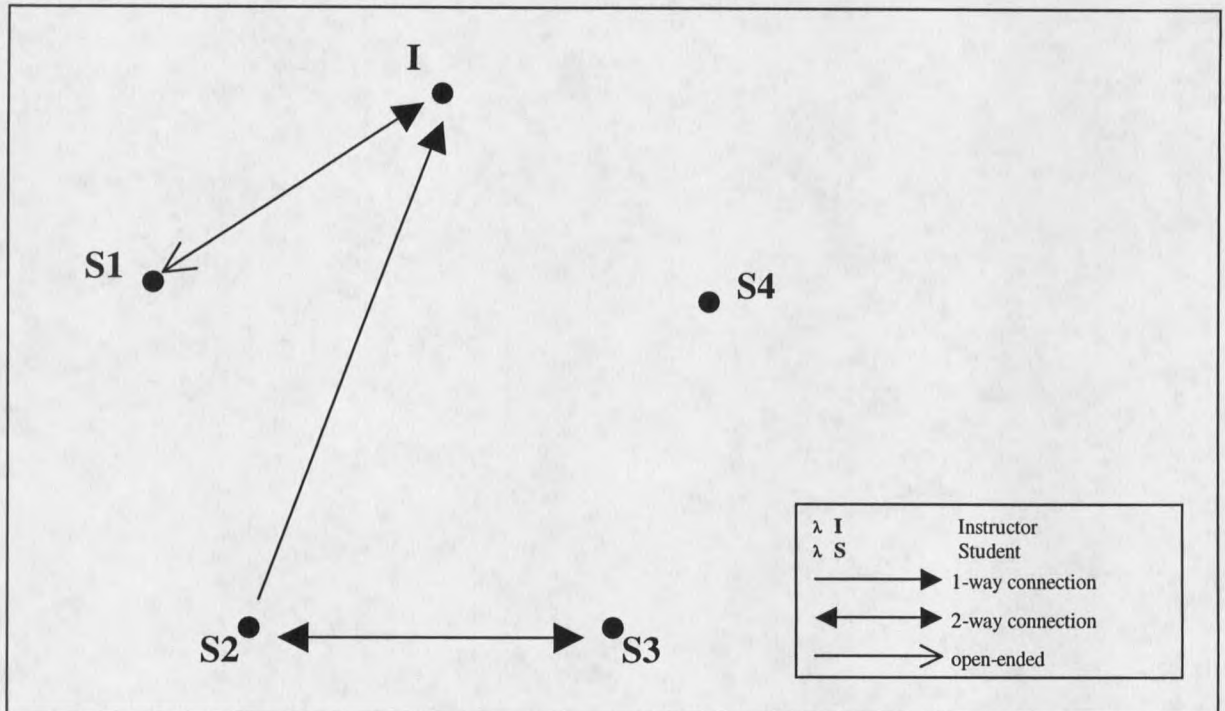


Figure 1  
Hypothetical Discussion Diagram

Three types of connections are possible in a discussion diagram. A connection is made between nodes if at least one communication takes place between two people. The exact number of communications that occurs is not represented in the diagram.

1. A one-way connection occurs if someone asks a question but receives no response (represented by a one-headed arrow);

2. A two-way connection occurs if the receiver responds to the question (represented by a two-headed arrow);
3. A connection is considered open-ended when a communication is phrased in such a way that anyone is welcome to respond; open-ended connections can be one-way or two-way (represented by an open arrow). (See Figure 1.)

The second step in the discussion diagram process involves calculating indices that describe the interactions. These indices provide measures of student participation and the extent to which the interactive potential is achieved. Measures of interactive potential are used to assess the relative contribution of instructor-student and student-student interactions to the discussion. Table 2 from Bickel (1999) provides a description of the formula for calculating each index.

Table 2. Discussion Diagram Interaction Indices

Index	Formula*
Student Participation	$\frac{\text{Total Number of Student Contributing at Least Once}}{\text{Total Number of Students in Discussion Group}}$
Total Interaction Potential	$\frac{\text{Actual Number of Connections}}{\text{Total Possible Number of Connections}^1}$
Instructor – Mediated Interaction Potential	$\frac{\text{Actual Number of Instructor-Student Connections}}{\text{Total Possible Number on Instructor-Student Connections}^2}$
Instructor – Independent Interaction Potential	$\frac{\text{Actual Number of Instructor-Student Connections}}{\text{Total Possible Number on Instructor-Student Connections}^3}$

\* All proportions are multiplied by 100 and represented as percents

<sup>1</sup> Total possible number of connections =  $(n^2 - n)/2$ , where  $n$  = number of nodes

<sup>2</sup> Total possible number of instructor-student connections =  $n_i * n_s$ , where  $n_i$  = number of instructor nodes and  $n_s$  = number of student nodes

<sup>3</sup> Total possible number of student-student connections =  $(n_s^2 - n_s)/2$

Table 3 shows the interaction indices for the discussion diagram in Figure 1 (Bickel, 1999).

Table 3. Interaction Index Calculations for Figure 1.

Index	Formula	Value
Student Participation	$(3/4)*100$	75%
Total Interaction Potential	$(3/10)*100$	30%
Instructor-Mediated Interaction Potential	$(2/4)*100$	50%
Instructor-Independent Interaction Potential	$(1/6)*100$	17%

Observation of Figure 1 and the results of Table 3 indicate that in this hypothetical discussion student participation was relatively high; however, only about one-third of the interaction potential was realized (three connections out of ten possible). In addition, the discussion was predominately instructor-directed as evidenced by the relative magnitudes of the instructor-mediated and instructor-independent interaction potentials, half of the possible instructor-student connections were made, while only one out of the six possible connections were made between students alone (Bickel, 1998).

Early discussion diagram mini-case study analysis on NTEN courses has been conducted by HRI (Bickel, 1998). In addition to confirming HRI observational data regarding online interaction, the discussion diagram case study suggests that the level of interaction in a course is not necessarily determined by course content; and that it is likely that the differences in online discussions were influenced by differences in course design. The case study also suggests that it is possible to quantify the differences between the online interactions of NTEN courses that are similar in some ways, but that differ considerably in elements of design and questioning techniques. Bickel (1998)

indicates that the link between course and instructor characteristics should be explored through further analysis of discussion diagrams in NTEN courses, and that interaction indices calculated from replicated discussion diagram analysis could be correlated to defining course design and characteristics that encourage interactive online environments.

Although there are limitations to the discussion diagram model (i.e. lack of data regarding frequency, sequence or quality of communication between nodes), it provides a vehicle for analysis of the online discussion that results from specific cognitive levels of instructor- initiated questions. In addition to quantifying the potential and reality for online interactions, the discussion diagrams provide faculty with an immediate visual impression and understanding of student response patterns that are occurring in their online discussions. Initial NTEN faculty observations of discussion diagrams indicate that they quickly grasp what is reflected in the diagrams and express interest and concern for increasing the student-initiated and student-student interaction potential for their online instruction (S. Smith and E. Taylor, personal communication, March 26, 1999).

Supplemental Course Reviews, Post-Course Evaluations,  
And Comparisons by Content Discipline

Supplemental Course Reviews

Supplemental course reviews were conducted on three courses from the study sample. This review was conducted in order to identify factors in course design that might contribute to the student-instructor and student-student patterns of interaction. In order to focus on courses which appeared to generate the most student-student interaction, the three courses with the highest scored for the instructor-independent

interaction index in each discipline were examined in detail. This supplemental review included an examination of course syllabus materials, course instructions and expectations of students, course organization, grading policies, online interactions, and post-course evaluations including both student and instructor comments.

### Post-Course Evaluations

In addition to the supplemental course review, post-course evaluation data on the selected NTEN courses were reviewed to glean insight regarding students' perception of the value of interaction with other students and with the instructor in the online classroom. Three post-course questionnaire items that most closely correlated with student perception of interaction and overall course satisfaction were identified by Dr. Sean Smith (1999) of Horizon Research, Inc. Lichert scale results and summaries for these three items, as well as interview comments from both instructors and students, were obtained from the post-course evaluations and reviewed in this study.

### Content Discipline

Following the course selection process, the sample courses were classified according to content discipline. All of the sample courses were classified into the three disciplines of physics, earth science and biology. Courses were coded by discipline in order to examine differences that might occur between disciplines and to allow comparisons of question frequencies, interaction indices, and post-course evaluation results between disciplines.

### Analysis

Following the classification of questions and the construction of discussion diagrams, analysis was conducted to answer each of the research questions. Although it was anticipated that this analysis would be primarily descriptive in nature, specific analysis procedures were not finally determined until the data collection was completed and an examination of the distribution and characteristics of the data was conducted.

Answers to the three research questions were determined as follows:

#### Research Question #1

What cognitive levels of questions were asked by instructors in the NTEN courses? The answer to this question was determined by identifying the total frequency of instructor-initiated questions for each course, the total frequency of questions by question level for each course and for the total sample. Based on the literature review of questioning techniques, question types, collaborative learning, and online instruction, it was anticipated that the majority of instructor-initiated questions would be classified at Levels I and II. Frequency comparisons were also conducted in order to determine similarities or differences in levels of questions asked during the early, middle, or final instruction phase of each course. The course samples were classified according to three content disciplines of physics, earth science, and biology, and question-level frequencies were compared across content disciplines.

### Research Question #2

What student-student and student-instructor response patterns occur as a result of specific cognitive levels of questions? The discussion diagrams and interaction indices established both a visual and quantitative description of the interaction patterns that resulted from each question. Interaction indices provided a quantitative summary for each of four areas of interaction. These included: total student participation, total student-instructor interaction potential, instructor-mediated interaction potential, and instructor-independent interaction potential. Means were calculated and compared for each interaction index. Four separate comparison of means by oneway analysis of variance were also conducted in order to compare interaction indice means by content discipline.

### Research Question #3

Is there a difference between cognitive levels of instructor-initiated questions and the resulting student-student and student-instructor response patterns in the NTEN courses? Four separate comparison of means by oneway analysis of variance were conducted in order to test the research question that questions at higher cognitive levels (low and high-convergent) would produce a greater percentage of participation potential in each of the interaction indices.<sup>1</sup> Specifically, the following null hypothesis is stated as  $H_0: \mu_i1=\mu_i2=\mu_i3=\mu_i4$  where  $i$ = a specific interaction index.

---

<sup>1</sup> It is recognized that a linear relationship exists within each course between the total-interaction index, instructor-mediated interaction index and the instructor-independent interaction index. However, these indices were analyzed separately, reflecting the descriptive nature of the study and the interest of the researcher in studying the individual communication patterns each index reflects.

The null hypothesis for total student participation was  $H_0: \mu_1=\mu_2=\mu_3=\mu_4$ ; for total interaction potential was  $H_0: \mu_1=\mu_2=\mu_3=\mu_4$ ; for instructor-mediated interaction potential was  $H_0: \mu_1=\mu_2=\mu_3=\mu_4$ ; and for instructor-independent interaction potential was  $H_0: \mu_1=\mu_2=\mu_3=\mu_4$ ; for which  $\mu_1$ = low-convergent,  $\mu_2$ = high-convergent,  $\mu_3$ =low-divergent;  $\mu_4$ =high-divergent cognitive levels of questions.

### Expected Results

Based on the literature reviewed (Wilén, 1991), it was anticipated that the results of this study would identify a majority of instructor-initiated questions at the convergent or low-cognitive levels of questioning. It was also expected that the cognitive levels of questioning would increase from the beginning to the end of the instructional timeframe in each course. It was anticipated that questions at higher-cognitive levels would produce higher means in 3 of the 4 interaction indices: total student participation, total-interaction potential, and instructor-independent interaction potential. The literature results regarding cognitive levels of questions and student achievement or involvement in discussion are mixed. However, several researchers have found that the use of higher-level questions increases student involvement in discussion, promotes discussion that is less dependent on instructor involvement, promotes student motivation and reflects an instructor's willingness to reduce control in the instructional process (Wilén, 1991; Klinzing and Klinzing-Eurich, 1988; Dillon, 1988; Wragg, 1984).

The matrix provided in Table 4 shows the four question levels and the four interaction indices. It was expected that there would be a statistically significant

difference at the .05 probability level between low-convergent questions (row 1) and high-divergent questions (row 4) for each column: 1) student participation, 2) total interaction potential, 3) instructor-mediated interaction potential, and 4) instructor-independent interaction potential.

Table 4. Matrix of Question Levels and Interaction Indices.

Cognitive Question Levels	Interaction Indices			
	Total Student Participation	Total Interaction	Instructor - Independent	Instructor - Mediated
I Low - Convergent				
II High - Convergent				
III Low - Divergent				
IV High - Divergent				

### Summary

This study identified the cognitive levels of instructor-initiated questions based on the Wilen system of question categorization, as well as the resulting student-student and student-instructor interaction patterns (as defined by interaction indices) from a sample of NTEN graduate online courses. The selected discussions were analyzed using a sociogram approach, constructing discussion diagrams in order to calculate quantitative values for student participation, total interaction potential, instructor-mediated interaction potential, and instructor-independent interaction potential for each discussion. An analysis of question levels and the interaction indices was conducted in order to identify patterns or relationships that may exist between the cognitive levels of questions asked by instructors, and the resulting online dialogue between students and instructor. In addition, the analysis compared question levels and interaction indices that occurred in three content disciplines and at the early, middle and late stages of course instruction.

Additional descriptive information was obtained from post-course evaluation data and detailed supplemental reviews conducted on the three sampled courses that generated the highest score for instructor-independent interaction.

The study utilized existing electronic transcripts from selected NTEN graduate online courses delivered over the past several years. These courses were similar in respect to graduate student population, technical design and support, number of participants, and instructor requirements for online participation. In addition, all course content was limited to biological and physical sciences in order to minimize the variability of questioning techniques and applicability across content disciplines. The instructor-initiated questions from each course were identified and used in the study, providing that the resulting dialogue could be clearly identified by a software-constructed dialogue thread.

The study was an initial attempt to understand the cognitive levels of questions that are used in online instruction and how the various levels of questions might influence student-student and student-instructor interaction patterns.

## CHAPTER FOUR

### RESULTS

#### Introduction

The purpose of this study was to identify the cognitive levels of questions asked by instructors in a sample of online graduate science courses and to determine if there was a relationship between the cognitive level of the question and the corresponding student-instructor and student-student interactions that occurred.

Descriptive quantitative analyses including frequencies, comparison of means, and one-way analysis of variance were used to answer the three questions proposed in the study:

- **Research Question #1:** What cognitive levels of questions were asked by instructors in the courses?
- **Research Question #2:** What student-student and student-instructor response patterns occur as a result of specific cognitive levels of questions?
- **Research Question #3:** Is there a relationship between cognitive levels of instructor-initiated questions and the resulting student-student and student-instructor response patterns in the courses?

The process of classifying instructor-initiated questions, calculating interaction indices, and constructing discussion diagrams is described. Question levels were compared with the means of the interaction indices in order to determine if there was a

statistically significant difference in the interaction patterns that occur as a result of each of the four question levels. In order to establish a more complete picture of the interaction patterns in the selected courses, question levels and interaction indices were compared by content discipline and with post-course evaluation results.

In addition to the quantitative analysis, a supplemental course review was conducted on each of three courses in the sample in order to better identify and understand course design characteristics that might have influenced student interaction patterns and the resulting interaction indices in the courses.

This chapter is organized as follows:

- Selection of courses;
- Selection of instructor-initiated questions;
- Descriptive analysis of question levels;
- Descriptive analysis of interaction indices;
- Comparisons with post-course evaluations
- Results of supplemental course review;
- Summary of the findings.

### Course Selection

Courses for this study were selected from a pool of courses offered by the National Teachers Enhancement Network program at Montana State University-Bozeman. All of the courses selected for the study met the following criteria:

1. Courses utilized the FirstClass<sup>TM</sup> CMC software for course interaction;

2. The course was not a repeated offering of a previously selected course;
3. Class size ranged from 12-20 participants;
4. The instructor required students to participate in some form of online interaction as a part of their overall course grades;
5. Faculty and students had been informed that the NTEN courses were part of an NSF funded program in which the content might be observed and utilized for research purposes; and,
6. The course discipline involved the biological and physical sciences.

The total pool of NTEN courses consisted of 39 courses. A review of each course was based on the above criteria and resulted in 16 courses to be used for the identification of instructor-initiated questions in this study. Courses were all taught by MSU faculty or faculty from other institutions contracted to teach for MSU. The complete pool of courses, criteria for selection, and the selected courses are listed in Appendix A. One course, Terrestrial Ecology of Plains and Prairies, was eliminated later in the study when a review of instructor-initiated questions revealed that it was impossible to link the questions with the corresponding discussion threads. It was determined that the course was organized in such a fashion that no meaningful data could be obtained. The remaining fifteen courses were ultimately used in this study.

#### Selection Of Instructor-Initiated Questions

Following the course selection process, electronic transcripts, or files of all course interactions, were obtained for each of the selected courses. The “find” command search

function of the FirstClass<sup>TM</sup> software was used to first identify all postings in the course that were made by an instructor or teaching assistant. Each of these postings was then reviewed to identify all instructor-initiated messages that contained a question or discussion topic that was posed to the entire class or to a specific discussion group. This review resulted in 222 total questions that could be distinctly identified and that could be linked to a specific discussion thread of responses to the question.

Following an initial review of the questions, it was determined that there were 13 questions that were not acceptable for the study leaving a total population of 209 questions for the study. In some cases the instructor posed a question that resulted in responses that were not linked in any organized thread, making it impossible to construct meaningful discussion diagrams and interaction indices from those questions. There were also instances when multiple questions were grouped together and responses could not be separated clearly enough to link specific questions with specific responses. In a very few cases, instructors posted questions and requested that responses be returned to them as private messages. These responses, therefore, were never posted to the entire class as a discussion thread, again making it impossible to construct a discussion diagram from the responses to those particular questions.

In order to eliminate questions related to technical issues and course start-up procedures, it was initially anticipated that questions from each course would be selected from the time period in the transcripts following the first two weeks of the course start date. After a review of the electronic course files it was determined that this time delay was not necessary. There were very few instructor-initiated questions identified that

related to technical support or logistical issues, and those few questions were eliminated. Therefore, the pool of questions was drawn from start to finish in each course. Questions were coded as to the week they occurred in the course and sorted by timeframe of first, second, or final third of the course.

Each course used a similar structural organization within the FirstClass™ software, establishing separate electronic course folders for dissemination of information related to the course syllabus and requirements, weekly discussion, and technical support. A sample page identifying typical course organization in FirstClass™ is presented in Appendix C.

### Results Of Question Level Frequencies

#### Classification of Questions

Each of the 209 questions were subsequently classified according to the four levels of the Wilen (1991) hybrid question classification system: low-convergent, high-convergent, low-divergent and high-divergent. A check-list (See Table 1) of common question cues based on Bloom's Taxonomy (University of Victoria, 1996) was used in order to consistently classify each question based on the language and intent of each question. Since the Wilen system is based on Bloom's Taxonomy (Bloom, 1956), questions using key-words identified with Bloom's level of "knowledge" were categorized as low-convergent. Questions identified with Bloom's level of "comprehension and application" were categorized as high-convergent. Questions matching with Bloom's level of "analysis" were categorized as low-divergent, and

questions matching Bloom's level of "synthesis and evaluation" were categorized as high-divergent. In several instances, instructors were consulted regarding the intent of the question in order to verify the classification. Samples of the instructor-initiated questions, question cues, and resulting question classifications are listed in Appendix D.

#### Frequency of Questions by Cognitive Level

Frequencies of the resulting question classifications were developed in order to answer research question #1: **What levels of instructor-initiated questions are used in the online graduate courses?** The resulting question level frequencies indicate that out of 209 questions 10 questions or 4.8% of all questions were classified at the low-convergent Level (I). Level II or high-convergent questions accounted for 88 or 43.5% of the total. There were 60 low-divergent (Level III) questions or 28.7% of the total and 48 high-divergent (Level IV) questions or 23% of the total.

Table 5 provides the frequencies for each question level. Although the largest fraction of the questions occurred at the high-convergent Level II; cumulatively, divergent questions at the two higher cognitive levels accounted for 51.7% of the total questions.

Table 5. Frequencies of Question by Question Level

Question Level	Frequency	Percent	Cumulative Percent
I	10	4.8	4.8
II	91	43.5	48.3
II	60	28.7	77.0
IV	48	23.0	100.0
Total	209	100.0	

### Question Level and Time In Course

Question frequencies in each category were cross-tabulated with the time that the questions were asked in the course. This cross-tabulation is shown in Table 6. The largest fraction of questions across all levels of questions were asked in the first third of the instructional timeframe.

Table 6. Cross-tabulation of Question Level Frequency and Time in Course

	Time In Course	Count by Question Level				Total
		I	II	III	IV	
First Third	Count	6	37	23	17	83
	% Within Time of Q	7.2%	44.6%	27.7%	20.5%	100.0%
	%Within Category Type	60.0	40.7%	38.3%	35.4%	39.7%
	% of Total	%	17.7%	11.0%	8.1%	39.7%
		2.9%				
Middle Third	Count	3	30	21	17	71
	% Within Time of Q	4.2%	42.3%	29.6%	23.9%	100.0%
	%Within Category Type	30.0	33.0%	35.0%	35.4%	34.0%
	% of Total	%	14.4%	10.0%	8.1%	34.0%
		1.4%				
Last Third	Count	1	24	16	14	55
	% Within Time of Q	1.8%	43.6%	29.1%	25.5%	100%
	%Within Category Type	10.0	26.4%	26.7%	29.2%	26.3%
	% of Total	%	11.5%	7.7%	6.7%	26.3%
		.5%				
Total	Count	10	91	60	48	209
	% Within Time of Q	4.8%	43.5%	28.7%	23%	100.0%
	%Within Category Type	100.0	100.0%	100.0%	100.0%	100.0%
	% of Total	%	43.5%	28.7%	23.0%	100.0%
		4.8%				

Results of a oneway analysis of variance (Table 7) indicated that there was no significant difference ( $p = < .05$ ) in the average number of questions by cognitive-level during the first, middle, or last third of the course.

Table 7. One Way ANOVA For Question Levels Asked at Early, Middle or Last Third of Course

Descriptives					
Question Level	N	Mean	Std. Deviation		
I	10	1.50	.71		
II	91	1.86	.81		
III	60	1.88	.80		
IV	48	1.94	.81		
Total	209	1.87	.80		

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.610	3	.537	.830	.479
Within Groups	132.639	205	.647		
Total	134.249	208			

\* $p < .05$

### Question Levels and Course Discipline

The next step in the analysis was to classify the selected NTEN courses according to content discipline and to compare the frequencies of question levels by disciplines. Each of the fifteen courses was categorized into one of the three disciplines: biology, earth science, or physics. Although the NTEN program has also developed and delivered courses in chemistry and engineering, none of those courses met the criteria for this study. This organization by discipline resulted in 5 courses in biology, 6 courses in earth science and 4 courses in physics. The following comparisons of questions in these

courses provides descriptive information, however, the results are not normalized by number of courses within each discipline or by number of credits in each course.

A comparison of frequencies revealed that the majority of all questions, 52.6%, were asked in the biology courses. This was followed by earth science courses with 28.2% and physics courses with 19.1% of the total questions. A cross-tabulation of question levels and course discipline is shown in Table 8.

Table 8. Question Level Frequency, Percent Within Discipline, Percent Within Level and Percent of Total By Course Discipline

Course Discipline		Course Level				Total
		I	II	III	IV	
Physics	Count	7	11	11	11	40
	% Within V18	17.5%	27.5%	27.5%	27.5%	100.0%
	% Within V3	70.0%	12.1%	18.3%	22.9%	19.1%
	% of Total	3.3%	5.3%	5.3%	5.3%	19.1%
Biology	Count	2	44	37	27	110
	% Within V18	1.8%	40.0%	33.6%	24.5%	100.0%
	% Within V3	20.0%	48.4%	61.7%	56.3%	52.6%
	% of Total	1.0%	21.1%	17.7%	12.9%	52.6%
Earth Science	Count	1	36	12	10	59
	% Within V18	1.7%	61.0%	20.3%	16.9%	100.0%
	% Within V3	10.0%	39.6%	20.0%	20.8%	28.2%
	% of Total	.5%	17.2%	5.7%	4.8%	28.2%
Total	Count	10	91	60	48	209
	% Within V18	4.8%	43.5%	28.7%	23.0%	100.0%
	% Within V3	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	4.8%	43.5%	28.7%	23.0%	100.0%

According to this analysis, the majority of questions in both biology and earth science were Level II or high-convergent questions. Physics showed an equal number of Level II, III (low-divergent) and Level IV (high-divergent) questions with 27.5% of the total questions asked in each of the three levels.

Within question levels, the highest percentage (70%) of all Level I (low-convergent) questions were found to be asked in physics courses. This was followed by

biology with 20% and earth science with 10% of all Level I questions. At the Level IV (high-divergent) question level, biology had 56% of all Level IV questions, followed by earth science and physics at 20.8% and 22.9% respectively.

Within course discipline, the highest percentage of all Level IV (high-divergent) questions were found in the physics courses, with 27.5% of all questions asked in the physics courses categorized at Level IV. Physics also had an equal percentage (27.5%) of Level II (high-convergent) and III (low-divergent) questions, and 17.5% of questions at Level I (low-convergent). Biology had 24.5% of all questions at Level IV, 33.6% at Level III, 40% at Level II and 1.8% at Level I. Earth science courses had 16.9% of the total questions at Level IV, 20.3% at Level III, 61% at Level II and 1.7% at Level I. Although the comparison of means provides interesting descriptive information about the cognitive levels of questions in various disciplines in the NTEN courses, a one-way ANOVA showed no significant difference ( $p < .05$ ) in question levels by course discipline. These results are provided in Table 9.

Table 9. One Way ANOVA for Question Levels by Content Discipline

Descriptives			
Discipline	N	Mean	Std. Deviation
Physics	40	2.65	1.08
Biology	110	2.81	.83
Earth Science	59	2.53	.80
Total	209	2.70	.88

Table 9. Continued

		ANOVA			
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.207	2	1.603	2.106	.124
Within Groups	156.803	206	.761		
Total	160.010	208			

\*p&lt;.05

### Interaction Index Analysis

Discussion diagrams, a sociometric tool, were used in this study to both visualize the interaction patterns and to calculate interaction indices in order to quantify the types of interaction occurring between students and instructors. Discussion diagrams were constructed for each of the 209 instructor-initiated questions identified in the study in order to answer research question #2: **What types of student-instructor and student-student interaction patterns occurred as a result of specific question levels?**

### Construction of Discussion Diagrams

The discussion diagram technique was developed by Horizon Research, Inc., in order to better quantify and visualize the types of interaction occurring in online instruction. Discussion diagrams and the associated interaction indices provide a measure of student participation and show the extent to which the interactive potential of a discussion is achieved (Bickel, 1999). The indices provide a measure of interactive potential and were used in this study to assess the relative contribution of instructor-student interactions and student-student interactions to the overall discussion initiated by each question in the study. Discussion diagrams were constructed by first identifying the

discussion thread and then analyzing the thread to determine the individual connections made between instructor-student and student-student as they responded to the question or discussion topic. The diagrams provide a visual tool that identifies all of the first-time connections made between the instructor and students in a given discussion thread.

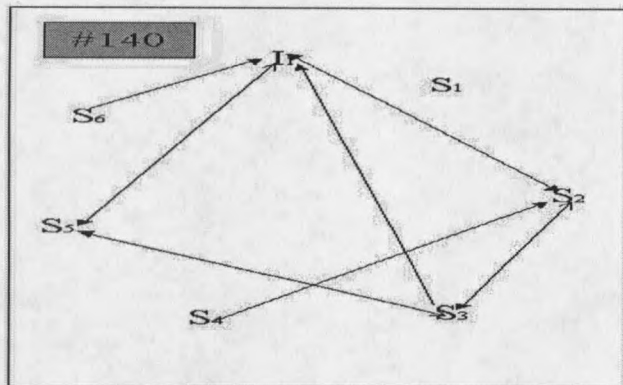
While discussion diagrams can be constructed from a discussion thread, the discussion thread cannot be reconstructed from the diagram. The diagram does not represent a total number of interactions or messages sent by participants, but simply establishes the existence of a single open-ended or closed connection made between individual students or between students and instructor. In many instances, multiple exchanges occurred between certain students or a given student and instructor, however, these are only represented as a single connection in the diagram. Variations on the diagram construction could be used to identify other variables in the study of online interaction.

Open-ended responses such as a question or request for additional feedback or information are represented in the diagram by an open arrow. Closed comments or statements which do not specifically invite response are represented in the diagram by a closed or solid arrow. Although the open and closed comment notations are not analyzed in this study, they provide a visual cue regarding the types of connections that are occurring between students and instructor. A sample of discussion diagrams from each content discipline and the associated interaction indices can be found in Appendix E.

### Sample Discussion Diagram

Figure 2 is an example of a discussion diagram constructed from question #140.

Figure 2. Sample Discussion Diagram from Question #140.



As in all the discussion diagrams analyzed in this study, it was assumed that the discussion in Figure 2 was started by an instructor-initiated question, that is not represented physically in the diagram. The results of the diagram in Figure 2 indicate that student 1 (S1) did not participate in the discussion at all. Student 2 (S2) connected with the instructor and with student 3. Student 3 (S3) connected with both students 2 and 5 and with the instructor. Student 4 (S4) only connected with student 2 and is the only other student besides S1 who did not respond to the instructor. Student 5 connected with the instructor and with student 3. Student 6 responded directly to the instructor and is the only student (besides S1) who did not interact with any other students.

### Calculating Interaction Indices

Following construction of the discussion diagrams, interaction indices were calculated for each question. Interaction indices were calculated for each of four potential interactions: 1) total student participation, 2) total interaction potential, 3) instructor-mediated interaction potential, and 4) instructor-independent interaction potential. Interaction indice calculations and the resulting values for question #140 shown in Figure 2 are illustrated in Table 10.

Table 10. Interaction Indices for Figure 2

Index	Formula*	Formula	Value
Student Participation	Total Number of Student Contributing at Least Once/ Total Number of Students in Discussion Group	(5/6)*100	83%
Total Interaction Potential	Actual Number of Connections/ Total Possible Number of Connections <sup>1</sup>	(7/21)*100	33%
Instructor – Mediated Interaction Potential	Actual Number of Instructor-Student Connections/ Total Possible Number on Instructor-Student Connections <sup>2</sup>	(4/6)*100	67%
Instructor – Independent Interaction Potential	Actual Number of Instructor-Student Connections/ Total Possible Number on Instructor-Student Connections <sup>3</sup>	(3/15)*100	20%

\* All proportions are multiplied by 100 and represented as percents

<sup>1</sup> Total possible number of connections =  $(n^2 - n)/2$ , where  $n$  = number of nodes

<sup>2</sup> Total possible number of instructor-student connections =  $n_i * n_s$ , where  $n_i$  = number of instructor nodes and  $n_s$  = number of student nodes

<sup>3</sup> Total possible number of student-student connections =  $(n_s^2 - n_s)/2$

The total student participation index is a measure of how many students responded to the question as compared to the total number of students who could possibly respond. This measure is calculated by determining the total number of students contributing at least once and dividing this number by the total number of students who could possibly contribute. The mean student participation index was .5845 for all

questions in this study indicating that on average, 58% of the students participated in instructor-initiated question in the NTEN courses studied.

The total interaction potential index provides a measure of the number of individual connections made between student-instructor and student-student as compared to the total number of individual connections that were possible. Unlike the total student participation index, which simply counts the number of students participating in the discussion, this index counts each first-time individual connection made between a student and another student or a student and the instructor. This calculation determines the total number of single (first-time) connections made between instructor-student and student-student, divided by the total number of possible connections. The mean Total Interaction Potential for all questions in the study was .1011 or an average of 10% of the total interaction potential was realized in instructor-initiated questions in the NTEN course sample.

The instructor-mediated interaction potential index is a measure of the total number of first-time student-instructor connections as compared to the total number of possible student-instructor connections. The calculation consists of determining the actual number of first-time instructor-student connections and dividing this number by the total possible number of instructor student connections. The mean indices for instructor-mediated potential was .4000 indicating that 40% of instructor-student interaction potential was realized in instructor-initiated questions.

The final interaction potential measured in this study was the index for instructor-independent interaction potential. This index reflects the number of first-time individual

student-student connections that were made, divided by the total number of individual student-student connections that were possible. The mean instructor-independent interaction potential index for the total group of questions in this study was .0582, or about 6% of the student-student interaction potential was realized as a result of instructor-initiated questions in the NTEN course sample. The means of the four interaction indices for each course in the study are included in Appendix F.

### Interaction Index Results

A comparison of means between each of the four interaction indices is shown in Table 11.

Table 11. Comparison of Means For the Four Interaction Indices

	Student Participation	Total Interaction Potential	Instructor- Mediated Potential	Instructor- Independent Potential
Mean	.5845	.1011	.4000	.0582
N	209	209	209	209
Std. Derivation	.2854	.1027	.2865	.1073

Total student participation in the discussions in this study show an average of 58% of all students participating in the discussions. Both the total interaction potential index and the instructor-independent interaction potential index appear quite low with 10% of the total interaction potential realized, and 5% of the instructor-independent interaction potential realized as a result of instructor-initiated questions. 40% of the potential instructor-mediated interaction was realized as a result of instructor-initiated questions.

The Relationship of Question Levels and Interaction Indices

One-way analysis of variance was conducted to answer question #3: **Is there a difference in each of the four interaction indices when compared across the four question levels?** A one-way analysis of variance resulted in a significant difference ( $p < .05$ ) between question levels and the two indices of total student participation and instructor-mediated interaction potential. The one-way analysis of variance showed no significant difference ( $p < .05$ ) between question levels and the two indices of total interaction potential and instructor-independent interaction potential. The comparison of interaction index means for each question level is provided in Table 12 and ANOVA results are given in Tables 13-16.

Table 12. Means of Interaction Indices for Each Question Level

Question Level		Student Participation	Total Interaction	Instructor-Mediated	Instructor-Independent
I	Mean	.2699	.0267	.1430	.0040
	N	10	10	10	10
	Std. Deviation	.1812	.0191	.1493	.0078
II	Mean	.6032	.1010	.4434	.0499
	N	91	91	91	91
	Std. Deviation	.2674	.0897	.2738	.0809
III	Mean	.5816	.1035	.4294	.0610
	N	60	60	60	60
	Std. Deviation	.2974	.1118	.3258	.1129
IV	Mean	.6181	.1138	.3345	.0818
	N	48	48	48	48
	Std. Deviation	.2887	.1192	.2430	.1452
Total	Mean	.5845	.1011	.4000	.0582
	N	209	209	209	209
	Std. Deviation	.2854	.1027	.2865	.1073

A comparison of means using one-way analysis of variance was conducted separately for each of the four interaction indices and the results are presented in Tables 13-16.

Table 13. One Way ANOVA For Student Participation By Question Level

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.079	3	.360	4.646	.004
Within Groups	15.942	206	.0774		
Total	17.021	209			

\*p<.05

Table 14. One ANOVA For the Total Interaction Index By Question Level

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.0631	3	.0211	2.029	.111
Within Groups	2.137	206	.0104		
Total	2.200	209			

\*p<.05

Table 15. One Way ANOVA for the Instructor-Mediated Interaction Index by Question Level

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.075	3	.358	4.597	.004
Within Groups	16.058	206	.0779		
Total	17.133	209			

\* p<.05

Table 16. One Way ANOVA for the Instructor-Independent Interaction Index by Question Level

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.0627	3	.0209	1.844	.140
Within Groups	2.336	206	.0113		
Total	2.399	209			

\*p<.05

A posthoc Sheffe test, shown in Table 17, indicated that the significant difference in total student participation and instructor-mediated interaction occurred between the category one (low-convergent) questions and the remaining three levels (high-convergent, low-divergent, and high-divergent).

Table 17. Posthoc Sheffe Test Results For Total Student Participation And Instructor- Mediated Interaction Indices.

Dependent Variable	(I) Category Type	(J) Category Type	Mean Difference (I-J)	Std. Error	Sig.
Total Student Participation	1	2	-.3333*	.0927	.006
		3	-.3117*	.0950	.015
		4	-.3482*	.0967	.006
	2	1	.3333*	.0927	.006
		3	.0216	.0463	.975
		4	-.0149	.0496	.993
	3	1	.3117*	.0950	.015
		2	-.0216	.0463	.975
		4	-.0365	.0539	.928
	4	1	.3482*	.0967	.006
		2	-.0149	.0496	.993
		3	-.0365	.0539	.928
Instructor-Mediated Interaction	1	2	-.3004*	.0930	.017
		3	-.2864*	.0954	.031
		4	-.1915	.0971	.276
	2	1	.3004*	.0930	.017
		3	.0139	.0464	.993
		4	.1089	.0498	.192
	3	1	.2864*	.0954	.031
		2	-.0139	.0464	.993
		4	-.0949	.0541	.382
	4	1	.1915	.0971	.276
		2	-.0189	.0498	.192
		3	-.0949	.0541	.382

\*p<.05

#### The Relationship of Interaction Indices and Course Discipline

The courses selected for this study were limited to graduate physical and biological science courses in order to reduce the potential differences that could be

attributed to instructional techniques that might be better suited to certain course content. However, it is still reasonable to expect that differences in interaction patterns might occur between course disciplines (Wragg, 1984). In order to better observe these differences, the interaction indices from courses in this study were grouped into the three discipline types of physics, earth science and biology. Oneway analysis of variance was then used to determine if there was a significant difference between each of the four interaction indices for each of the three course discipline categories of physics, earth science and biology. The means of interaction indices for each content discipline is shown in Table 18.

Table 18. Means of Interaction Indices for Each Discipline

Course Discipline		Student Participation	Total Interaction	Instructor-Mediated	Instructor-Independent
Biology	Mean	.6402	.1208	.4213	.0831
	N	110	110	110	110
	Std. Deviation	.2904	.1146	.3064	.1330
Earth Science	Mean	.6330	.1015	.5227	.0395
	N	59	59	59	59
	Std. Deviation	.2385	.0979	.2355	.0708
Physics	Mean	.3596	.0464	.1604	.0175
	N	40	40	40	40
	Std. Deviation	.2236	.0341	.1003	.0239
Total	Mean	.5845	.1011	.4000	.0582
	N	209	209	209	209
	Std. Deviation	.2854	.1027	.2865	.1073

A one-way ANOVA comparing course discipline and means for each interaction index did reveal significantly different results ( $p < .05$ ) for each of the four indices of total student participation, total interaction potential, instructor-mediated interaction potential, and instructor-independent interaction potential. The results of each ANOVA are shown in tables 19-22.

Table 19. One Way ANOVA for Total Student Participation by Discipline

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.504	2	1.252	17.858	.000
Within Groups	14.441	206	.0701		
Total	16.945	208			

\*p&lt;.05

Table 20. One Way ANOVA for Total Interaction by Discipline

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.162	2	.0812	8.226	.000
Within Groups	2.033	206	.0987		
Total	2.196	208			

\*p&lt;.05

Table 21. One Way ANOVA for Instructor-Mediated Interaction by Discipline

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.234	2	1.617	24.073	.000
Within Groups	13.839	206	.0672		
Total	17.073	208			

\*p&lt;.05

Table 22. One Way ANOVA for Instructor-Mediated Interaction by Discipline

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.155	2	.0775	7.123	.001
Within Groups	2.241	206	.0109		
Total	2.396	208			

\*p&lt;.05

The student participation index or the total number of students participating in the discussion, compared to the total number possible, was much higher in both biology and earth science (64% and 63% respectively) than it was in physics courses (39%). The total interaction potential, or the number of connections made between all students and instructors compared to the total number possible, was again twice as high in biology (12%) and earth science (10%) as it was in physics (5%). Earth science showed the highest mean results (52%) for instructor-mediated interaction potential (or the total number of instructor-student connections compared with the number possible) followed

by biology at 42% and physics at 16%. Instructor-independent interaction potential, or the number of student-student connections compared with the total student-student connections possible, again showed consistent comparisons between the three groups with biology at 8%, earth science at 4% and physics at 2%.

The primary difference in interaction indices occurred between physics and the other two disciplines. Physics courses had interaction means at only half the level of both earth science and biology courses. Biology and earth science courses, in which the majority of questions were classified at the Level II (high-convergent), resulted in higher amounts of interaction in both total-interaction potential and instructor-independent interaction potential. Physics, with an equal percentage of Level II, III, and IV questions, showed lower interaction percentages in all four indices.

#### Comparisons With Post-Course Evaluations

Throughout the NTEN project, Horizon Research, Inc. has maintained post-course evaluations completed by NTEN students on each course. Post-course evaluations were obtained from Horizon Research for each of the courses used in this study. According to conversations with Sean Smith, Horizon Research principal investigator, there are two evaluation questionnaire items that most closely relate to the issues of interaction in the online discussions (Smith, 1999b). The first item states, "Interactions with the course instructor(s) helped me understand the course material better." The second item states "Interactions with the course participants helped me understand the course material better." In addition, a third item which most closely parallels overall student satisfaction

with the course reads, "I would recommend this course to my colleagues" (Smith, 1999b). Each item is answered using a five-point lichert scale ranging from strongly agree to strongly disagree.

The overall averages for each of these evaluation items in the courses used in this study are relatively positive. For the total group of courses, 83% of students said that they agreed or agreed strongly that interactions with the instructor helped them understand the course material better. Eighty-four percent stated that they agreed or agreed strongly that the interactions with course participants helped them understand the course material better, and 78% said that they would recommend the course to their peers. Table 23 indicates the percentage of students in the courses in this study, that agreed or agreed-strongly with the evaluation items regarding student-student interaction, student-instructor interaction, and overall course satisfaction.

Table 23. Post-Course Evaluation Percentages of Students Agreeing or Agreeing-Strongly with the Variables Regarding Student Interaction, Value of Instructor Interaction and Overall Course Satisfaction.

Course	Stu-Stu	Stu-Faculty	Satisfaction
Biology of Riparian Zones & Wetlands	55%	89%	66%
Electric Hydrology	42%	75%	41%
Mineral Resources, Economics & Environ	85%	69%	76%
Plains Landscapes	89%	55%	66%
Nutrition For Fitness	100%	92%	84%
Teaching Adolescent Nutrition	89%	78%	77%
Dirty Dozen Soil Science	100%	73%	100%
Earth Systems Science	91%	81%	90%
Infection & Immunity	91%	90%	63%
Quantum Mechanics	100%	100%	100%
General Relativity	100%	100%	100%
Particle Physics	88%	95%	88%
Science & Photography	83%	91%	100%
Agriculture & Medical Biotechnology	57%	78%	36%
Total Mean Results	84%	83%	78%
Biology Average	78%	85%	65%
Earth Science Average*	81%	75%	77%
Physics Average	93%	97%	97%

\*No evaluation data were available for the Mountain Plains & Riparian Processes Course.

A more detailed examination of evaluation means was conducted for each of the three course disciplines. Physics courses, which showed lower interaction indices than the other two disciplines, had higher evaluation scores on all three items for value of student-instructor interaction (97%), value of student-student interaction (93%) and willingness to recommend the course to peers (97%). Biology results showed 85% agreeing or strongly agreeing that the student-instructor interactions helped them understand the content, 78% agreeing or strongly agreeing that the student-student interactions helped understand the content, and 65% recommending the course to their peers. Earth science courses, which ranked equal to biology courses on the interaction indices, and ranked highest of all the disciplines in terms of instructor-mediated interaction, showed 75% for value of student-instructor interaction, 81% for value of student-student interaction, and 77% willing to recommend the course to their peers.

In the most recent NTEN annual evaluation report, Smith (1999) cited several student quotations indicating that participants see the discussion as critical to their learning, and credit both the instructor and other participants with facilitating their learning:

The interaction with and between the other class participants [was the most effective aspect of this course] for two reasons: 1) It allowed me to gain ideas (in both the course content and in educational approaches and philosophy) from several different people, with widely different backgrounds. This provided a much richer experience than would have been possible through a local campus course. 2) It allowed me to contribute, as well, to other people's experience, and to realize that my own unique background could, in turn, be an asset to others.

One of the most valuable aspects was to see the types of confusions that could occur when attempting to learn the subject. It was helpful to discuss the misconceptions with people who were willing to share their

misconceptions and difficulties, which is not always the case when your students encounter the same difficulties.

Smith (1999) also cited quotations that illustrate student frustration when discussion falls short of their expectations:

I wish there could have been more dialogue going on. It seemed that most participants were more intent on just getting the assignments done and that was it...many questions were left hanging in the air and never answered.

There needs to be more guidance during the group discussions of homework. We stumbled around in the dark a lot, and there were times where we came to erroneous conclusions, but were never corrected. This is not the way to dispel misconceptions, and is not the way inquiry is taught in the classroom. There needs to be more staff so that one staff member can be assigned to a group and actively guide weekly discourse on the tutorials.

### Results Of The Supplemental Course Reviews

There are many factors that influence student and instructor interaction patterns in any given course. Many of those factors are related to the course design and instructional style determined by the instructor. In order to better understand how design factors might influence the student-student and student-instructor interaction in an online classroom, three courses from this study were selected for a more detailed review. Supplemental course reviews were conducted on the course from each discipline that had the most student-student interaction as a result of discussions that occurred following instructor-initiated questions. The selected courses were Earth Systems Science (earth science), Quantum Mechanics (physics), and Teaching Adolescent Nutrition (biology).

## Quantum Mechanics

Course Design: The quantum mechanics course was taught Fall semester 1999 by one faculty member and one teaching assistant. Student enrollment consisted of 15 students who enrolled for three graduate credits. The course ran for a total of 14 weeks. This course has been taught multiple times by the same instructor throughout the NTEN program.

Course policies were clearly defined from the beginning. Students were provided detailed written information regarding the description, instructor, prerequisites, work load, dates and credit, technical support, electronic delivery, and learning materials. In addition, students received lengthy information regarding the “challenges of an electronic course,” the format for discussion, and the role of the instructor and student.

The role of the instructor was described in the introductory policies:

The instructor in this course does not lecture, but rather helps focus the discussion on the reading and exercises for the week and provides guidance to the group from time to time. As a discussion on a particular topic develops, you will notice that some questions put to the instructor are turned back to the class for resolution, since mulling over and answering such questions is one of the best ways to learn. There is much talent and understanding among all the course participants, and one of the goals of this course is to take advantage of these. (Thornber, 1999)

Student roles were also defined with an emphasis on course discussion: “It is important for you to understand that your role in this class is not to be a passive note-taker – because there is to lecture on which to take notes! Each participant is expected to read the material, to be prepared for ongoing discussion, and to offer help and

suggestions to others in the class. Each member of this class shares equally in the responsibility for the successful completion of the course.” (Thornber, 1999)

Both assignments and grading policy were also clearly identified in detail, and again, emphasized the importance of online discussion: Each week a different student was assigned the role of “First Responder.” The First Responder read the weekly assignment and posted a discussion topic to the class by a given deadline. Detailed directions were given for where these topics and the responses should be posted in the electronic classroom. Another requirement involving online discussion was called the “Reading Memo.” For each weekly reading assignment, students were required to send a brief memo to another student summarizing their reactions, questions, and insights regarding the reading. Students responded to the “Reading Memo” that they received. “Reading Memo” recipients were rotated each week so that students interacted with a different classmate each week. Again, detailed information was provided regarding where to post these “Reading Memos” and the responses in order to receive credit for grading purposes.

In addition to the First Responder and Reading Memo requirements, students also had weekly homework exercises and, once again, emphasis was placed on online interaction: “Participants are urged to send messages to other members of the class and to collaborate on homework and projects... You may also contact the instructor by private message at any time to ask questions, make comments, or shoot the breeze.” (Thornber, 1999).

Introductory materials provided students with a detailed checklist of weekly requirements and deadlines. Students knew exactly what was expected of them and when it had to be completed each week. A clearly-outlined point system was provided for grading: Out of a total 275 points, 110 points or 40% were related to the online interaction resulting from First Responder topics or Reading Memo responses. The remaining 60% was related to weekly homework assignments or projects. The final grading scale was also clearly defined and based on total points earned. Students were urged to contact the instructor regarding unforeseen circumstances that prohibited them from meeting deadlines or requirements, and each participant was provided with a weekly progress report showing points earned and projected grade based on current point status.

Electronic Classroom Organization: The Quantum Mechanics course was organized into eight major folders. These folders included: QMBulletins, QMAssignments, QMMaterials, QMTopics, QMTechnical, QMReading, QMHomework, and QMDiscuss. The “bulletins,” “assignments,” and “materials” folders contained course policy, assignments, reading materials, and introductory information. The “technical folder” was included to manage any software or hardware related questions. “Topics” and “discuss” folders included online interactions related to the Reading Memos and First Responder topics. Weekly discussion topics were clearly defined by the instructor and the related reading assignment each week and the sub-folders were organized into weekly discussion topics. The “reading” and “homework” folders were

provided for submission of homework and copies of reading memos in order to receive credit for their completion.

Course Statistics: Seven instructor-initiated questions were identified in the Quantum Mechanics course with three Level IV (high-divergent) questions, three Level III (low-divergent) questions, and one Level II (high-convergent) question. Interaction indices based on these seven questions showed the following results: total student participation = 44%, total interaction potential = 7%, instructor-mediated interaction potential = 19% and instructor-independent interaction potential = 4%. The FirstClass™ software recorded a total of 3,585 messages posted to the eight main course folders and this count does not include any private messages sent between students and/or instructors. This high message count indicates that the majority of online interaction did not occur as a result of the seven instructor-initiated questions.

Post-course evaluations indicated that 100% of the students responding to the evaluation agreed or strongly agreed with each of the three evaluation statements analyzed in this study. Participants all agreed or agreed strongly that interaction with the instructor helped them understand the content, interaction with other students helped them understand the content, and that they would recommend the course to their peers.

When asked what aspects of the course were especially effective, several student comments refer to the online interaction with the instructor and their peers:

I learned about the theory of the interaction between light and matter, a very powerful model. The course has also helped keep my mind open and receptive to new ideas from the instructors and participating colleagues. I hope to extend this openness to help my teaching.

The exercises were well thought out. The course was well designed with discussion and participation being an integral part of the weekly assignments.

When asked how the course could have been more effective, several students' comments indicated a desire for more structure, perhaps reflecting their traditional expectations for a lecture format:

I would like to have more structured discussions begun by the instructors. Many of the discussions started by students tended to digress into ramblings.

Although the course is not designed to include lectures, I think I would have gotten more from the course if we would have had lecture materials available to us. In particular, I think it is a shame to get through a course like this without seeing [the instructors] lecture on some key topics in QM.

Discussion Diagrams and Instructor-Initiated Questions: The search for instructor-initiated questions in the Quantum Mechanics course resulted in relatively few instructor-initiated questions when compared with other courses in the study. This is explained by the fact that the instructor attempted to play a limited role and required students to initiate the majority of questions and discussion topics. A review of the discussion diagrams indicates that the majority of responses are "closed" statements that do not invite further dialogue. Questions which asked students to reflect on a reading assignment or software calculation exercise, (i.e. What are some of the main points that Feynman has made?), appeared to generate responses from a greater number of students and more responses between students, than questions that asked students to apply the information to a different context (i.e. Can people think of other scenarios?).

### Teaching Adolescent Nutrition

Course Design: The Adolescent Nutrition course was taught fall semester 1999 with one faculty instructor, one teaching assistant and 25 students. This course ran for a total of 14 weeks and was approved for two graduate credits.

Course introductory materials included information on goals, sponsorship, instructors and staff, dates, credit, materials, prerequisites, dates and time commitment, and course structure. Structure information included detailed descriptions of online discussion expectations, deadlines, grading, and homework.

The instructor placed special emphasis on discussion and interaction throughout the introductory materials. When describing goals the instructor wrote, "A secondary goal of the course is to enhance your comfort level with online continuing education course offerings such as this one." In describing the roles of student and instructor, discussion was also emphasized: "Each participant plays an important role in the overall success of the course due to the great importance of the discussion component of the course. The discussion is at the core of the course and each participant should be prepared to actively play a role in the ongoing discussions. This is not only a wonderful medium through which to learn about new content, it also serves very well as a means of sharing instructional/educational experiences with colleagues who otherwise would not be so accessible. Please take advantage of this effective communications system."

Course assignments included a weekly reading assignment, weekly discussion item, and periodic homework assignments. Participants were required to contribute twice

in each weekly discussion. Homework assignments and projects were submitted directly to the instructor.

Grades were based on discussion participation, homework, and a final project. Participation in online discussion was again emphasized: "The discussion component of the course will serve as the platform on which we bring together our unique histories, interpret the new material we have read and ponder various intriguing aspects of this exciting topic" (Stein, 1999). Grading for discussion was based on quality as well as quantity. Students could earn up to 10 points each week for discussion contributions. Discussion points accounted for 35% of the total grade. Online contributions were also required through the use of discussion summaries. Each week a different student was assigned the responsibility for summarizing the week's discussion and posting highlights and conclusions to the rest of the class. Points for the discussion summary accounted for 7% of the total grade. Homework assignments and a final course project accounted for the remaining 58% of the student's grade. Point tallies and grade summaries were posted electronically, periodically, throughout the course.

Electronic Classroom Organization: The Adolescent Nutrition course was organized into 22 main folders, with the majority of folders organized around weekly discussion topics. In addition to the folders, the course contained several additional folders for instructional support. The "general info" folder contained all course policy and introductory material. A "technical dilemma" folder provided a location for software and hardware questions, and a "grade report" folder contained periodic postings for student grade point status. The "homework in-box" housed all completed homework

assignments and the “survey in-box” collected pre-course surveys. Three additional folders provided opportunity for online student interaction. The “Who’s in Class” folder encouraged students to introduce themselves to one another and to share information about themselves. “Hot Topics” was an area where students could continue to pursue weekly discussion topics or any other topic with other participants. A “cool materials” folder provided participants with a place to share classroom resources that might help them present course topics to students in their own classrooms.

Course Statistics: The FirstClass™ software recorded 1,556 public messages posted throughout the entire course. Twenty-three instructor-initiated questions were identified in the nutrition course. Question levels were categorized with 6 questions at Level II (high-convergent), 4 questions at Level III (low-divergent) and 13 questions at Level IV (high-divergent). Interaction index means that resulted from the instructor-initiated questions and their related discussions were 91% total student participation, 28% total interaction potential, 34% instructor-mediated interaction potential, and 27% instructor-independent interaction potential.

Post-course evaluation results indicated that 89% of the respondents agreed or agreed strongly that interaction with the course instructor helped them understand the content. Seventy-eight percent agreed or agreed strongly that interaction with other students helped them understand the course content, and 77% agreed or agreed strongly that they would recommend the course to their peers. When asked what aspects of the course were particularly effective several students commented on the online discussions.

I have gained useful information and activities for my classroom. Also, the collaboration has increased my resources and support system for teaching. The material used is incredibly valuable to my profession.

I liked the structured discussions twice a week. This made me stay on top of things instead of dedicating a weekend to completing the course work. I also liked the different discussion groups. Each week (almost) we had different groups which brought about different perspectives.

Discussion questions encouraged me to think about my ideas and concepts and how they related to the whole picture and how I could influence students in a positive way.

Similar to the comments in the quantum mechanics course, several students expressed a desire to change the discussion format. One wrote: "I would like to see the discussions in a more open-ended format. Too much structure squelches the true discussion that could take place." Another commented, "I felt a lack of interaction with fellow class members. Immediate feedback is lacking. Guess I really like the social interaction in a classroom." (Horizon Research, Inc. 1999) Another comment reflects expectations for a traditional classroom, "Cut the weekly workload down, insure greater content for less time investment."

Discussion Diagrams and Instructor-initiated Questions: A review of the discussion diagrams revealed several differences from discussion diagrams in other courses. The course design was dependent on weekly or more-than-weekly discussion questions and topics posted by the instructor resulting in a larger number of instructor-initiated questions than found in other courses. Students were divided into small discussion groups of six or seven students for each question, and these groups were re-assigned weekly in order to encourage students to interact with a larger variety of

individuals in the course. The small discussion groups seemed to encourage students to interact with every individual in the group.

The most striking difference in the discussion diagrams for the Adolescent Nutrition course is the large number of "open-ended" comments that invited further discussion. It appears that this is strictly a result of course-design. Each student was required to respond to the original instructor-initiated question AND to follow-up with a new question to the discussion group. In many diagrams, it appeared that this technique was effective for increasing the amount of interaction that occurred between the course participants as they responded to questions posted by their classmates within the dialogue.

### Earth System Science

Course Design: The Earth Systems Science course was offered for two graduate semester credits in Fall semester 1999. The course was taught by one faculty instructor to 20 participants over 14 weeks. Unlike the previous two courses described in the supplemental review, this course used a combination of material presented on the WWW and the FirstClass<sup>TM</sup> software for online course discussions and interaction.

Introductory materials, syllabus, and assignments were provided on the course web site. Communication was emphasized by the instructor throughout this material: "The bottom line is communication: you must communicate with me in order for your questions to be answered and for this class to be successful for you!" In describing course requirements for participation in discussion, the instructor wrote,

The value of a class such as this is the opportunity to participate in discussions of science and pedagogy issues. Participating in a discussion with your fellow professionals and instructors can inspire you, rekindling the sense of wonder about science that you felt as a young student. The discussion questions are high-level, fundamental questions about the Earth as a System of Systems. Understanding the mechanisms and being able to discuss the material at this level is an indication that you have a good understanding. I place high value on enthusiastic and open, no-holds-barred debate of ideas and issues. Communicating asynchronously via e-mail may seem somewhat stifling. However, you will find that it forces you to stop, gather your thoughts, and really think about responses.

Course assignments, grading procedures, deadlines, and schedules were described clearly and in detail. Fifty percent of the grade was based on some kind of activity that required online communication. This communication was partly made up of contributions to discussion topics, posting summaries of results of classroom activities, and critiquing work done by fellow participants. Students were required to make at least one posting to the weekly discussion and to reply at least once to someone else's posting. The remaining 50% of the grade was derived from class projects that applied the course content to an area of interest to the participant. Similar to the other courses in this case study, the Earth Systems Science instructor placed special emphasis on the individual student's responsibility for learning. "I am a firm believer in participatory education at all levels. In the spirit of innovation and freedom from the tyranny of grades, you choose the grade and level of participation you want. The quality and quantity of your participation is, of course, strictly up to you; you will get far more from this course if you participate fully!"(Nelson, 1999).

Another similarity to the previous two courses is the overall tone of the introductory material. In each case the instructor was welcoming, upbeat, energetic and

enthusiastic about the course. Students were given the impression that the course was serious in content and the instructor cognizant of the interests and needs of the particular audience. Communication with the instructor was always encouraged: "Please contact me as soon as possible if you feel yourself getting behind, confused, discouraged, or bored. I must warn you, however, that I am eternally optimistic and insufferably cheerful!"(Nelson, 1999).

Electronic Classroom Organization: As previously stated, this course was organized into two parts. The first part contained course information and materials located on a web site. This section of the course included the "introduction," "syllabus," "assignments," "helpful technical hints," and "people: meet your instructors and classmates." This last section provided students with the opportunity to share a photo and information about themselves with their classmates.

The second part of the course used the FirstClass™ software to facilitate online communication and discussion. There were nine main folders, organized by course units and assignment areas. In addition, there was a "coffee shop" folder established for student discussion, independent of specific course discussion topics. Course units were not organized by week, but rather by topic, with four main discussion topics presented throughout the course. These topics were quite broad and discussion for each topic ranged over a two to three week time period.

Course Statistics: The FirstClass™ software recorded a total of 791 public messages posted throughout this course. A search for instructor-initiated questions

revealed only four questions posted by the instructor, one for each unit. These broad questions often contained multiple questions, but were recorded as one—as long as they were consistent in level or category. It was not possible to separate the responses into mini-questions asked within questions. Of the four instructor-initiated questions, two were categorized at Level II (high-convergent), one at Level III (low-divergent), and one at Level IV (high-divergent). Students were divided into small discussion groups for all questions except one.

Interaction indices for Earth Systems Science show 91% total student participation, 38% total interaction potential, 90% instructor-mediated interaction potential, and 24% instructor-independent interaction potential. Post-course evaluation results indicate that 91% of the students responding agreed or strongly agreed that interaction with the instructor helped them understand the content and 81% agreed or strongly agreed that interaction with other students helped them understand the content. Ninety percent agreed or strongly agreed that they would recommend the course to their peers.

Student comments expressing the value of online interaction with peers and the instructor were fewer in the Earth Systems Science course as compared to the Quantum Mechanics or Adolescent Nutrition course. One student commented that, “developing the lessons [was the most valuable] because the feedback from the instructor was very valuable.” One student wrote: “The discussions were so frustrating. The topics were so abstract. Many times I was lost in the discussion. I did not even know where or how to begin to answer such difficult questions. It would be better to ask some questions that

could be researched.” Yet another student noted that the discussions were valuable and recommended that more time be allotted to discuss [assignments] as a group, “I would have liked...more time to look at each others’ extensions and analyze them as a class and make several great units together out of them that many of us could use in our classrooms. Two heads or ten heads are often better than one.”

Discussion Diagrams and Questions: Although the Earth Systems Science course design placed special emphasis on discussion and participation, a review of the instructor-initiated questions and discussion diagrams revealed that there were very few instructor-initiated questions. These questions were all constructed as multiple questions within questions, and probe students to elaborate on their responses and build on previously learned material. For example, one question reads “Discuss how plate tectonics helps us understand the evolution of the earth, discuss what models you would use to show vastness of scale represented by plate tectonics?” This questioning technique called scaffolding, is described by Jiang (1998) as having a correlation with positive student course perception. A single question of this type was used by the instructor to generate discussion for longer periods of time, sometimes up to two or three weeks in the course. Although this technique appears to enhance interaction among and between students, the response postings are almost 100% “closed” comments, similar to the “open” and “closed” results in the other two courses.

### Summary of Findings

The main findings of this study can be summarized as follows:

- The majority of instructor-initiated questions in the course sample are Level II, or high-convergent level questions; however, when questions were divided into two levels of convergent and divergent, the largest percentage of questions occurred at the divergent or high-cognitive level of classification.
- There was no significant difference ( $p < .05$ ) in the cognitive-level of instructor-initiated questions recorded during early, middle, or late time periods in the sample of courses.
- Interaction means for both total interaction and instructor-independent interaction indicated that the amount of interaction between participants was low when compared to the total amount possible; however, these indices show that students were equally or more likely to interact with a fellow student, as they were with the instructor in response to instructor-initiated questions.
- The post-course evaluations consistently indicated that students perceived benefit from the interaction with their peers and instructors, and that instructors perceived a high level of student-student interaction in the sampled courses.
- Questions at the cognitive levels of high-convergent, low-divergent, and high-divergent showed significantly different results ( $p < .05$ ) in both the total student participation index and instructor-mediated interaction index. Questions at the higher cognitive levels appear to increase the probability that each student in the course would participate in the discussion and the likelihood that the instructor would

interact with each individual student in the course. There was no significant difference ( $p < .05$ ) between the cognitive level of question and either instructor-independent interaction or total interaction indices.

- Interaction indices and cognitive levels of instructor-initiated questions in the courses may be influenced by content discipline. Biology courses showed the largest number of instructor-initiated questions. Both biology and earth science courses had higher scores in all four indices of total student participation, total interaction potential, instructor-mediated interaction potential, and instructor-independent interaction potential as a result of instructor-initiated questions. In addition, both biology and earth science courses had a majority of high-convergent questions, whereas physics had the highest percentage of low-convergent questions of all disciplines, and an equal distribution of high-convergent, low-divergent, and high-divergent questions.
- Supplemental course reviews, conducted on the courses in each discipline with the highest instructor-independent interaction indices, provided insights regarding course design factors that may influence student-student and student-instructor interaction. Although levels of questioning and interaction indices appear to be influenced by course discipline, it is more likely that overall course design factors are responsible for these differences.

Conclusions related to these findings and the implications for theory, practice, and research are described in Chapter 5.

## CHAPTER FIVE

### CONCLUSIONS

#### Introduction

Rapid advances in information and communication technologies have rekindled and spurred interest in the use of instructional technologies to deliver courses at a distance to students in higher education. Attempts at distance learning in higher education have met with mixed success over the years. Most of these efforts utilized instructional technology that offered a limited one-way broadcast medium. Satellite, public television, and print correspondence courses all created a "top-down" or broadcast delivery form of teaching and were seldom successful in engaging and immersing students in the learning process. Now, however, new technical advancements, with two-way interactive video, audio, and text capabilities, offer an opportunity to create a learning environment that may equal or ultimately surpass that of a traditional classroom.

According to the literature reviewed for this study, there is ample descriptive evidence regarding the advantages and appropriateness of computer-mediated conferencing for teaching and learning (Harasim et al., 1995; Driscoll, 1994; Berge, 1997a). With the introduction of the World Wide Web, there has been a proliferation of courses using computer-mediated conferencing as a component of the course delivery. Although it has been demonstrated that computer-mediated conferencing can be an effective teaching/learning medium ideal for engaging students in the learning process,

little is known about specific instructional and course design techniques that might be utilized in this environment to maximize the opportunities for teaching and learning (Berge, 1997a, 1997b).

The purpose of this study was to identify the cognitive levels of questions asked by instructors in a sample of online graduate science courses and to determine if there was a relationship between the cognitive level of the question and the corresponding student-instructor and student-student interactions that occurred. The distance learning literature reviewed for this study indicates that the majority of practitioners and researchers of online and computer-mediated instruction subscribe to the social-constructivist theory of learning (Kanuka and Anderson, 1998). If the online medium is expected to facilitate learning through students' interaction with new information and with other individuals, it is important to understand these instructional techniques that might encourage students to interact with one another and facilitate the integration of new knowledge with their existing knowledge and prior experience.

This study consisted of three parts: 1) identifying and classifying instructor-initiated questions in a sample of online courses; 2) constructing discussion diagrams and calculating interaction indices for instructor-student and student-student interactions; and 3) conducting supplemental reviews on a subset of courses in order to better understand design factors that might contribute to student-student interaction. Analysis was also conducted on post-course evaluation items that corresponded most closely with participants' perceived value of interaction with the instructor and fellow students in the online courses.

This chapter is organized as follows:

- Conclusions regarding frequencies of question levels;
- Conclusions regarding interaction indices;
- Conclusions regarding supplemental course reviews;
- Conclusions regarding NTEN evaluation data;
- Discussion of conclusions as they relate to the literature; and
- Implications for theory, practice and research.

### Conclusions

#### Conclusions Regarding Frequencies Of Cognitive Levels of Questions

Research Question #1: What cognitive levels of questions were asked by instructors in the NTEN courses? There was an equal distribution between low and high-level cognitive questions asked by instructors in the courses studied. A total of 209 instructor-initiated questions were identified from fifteen online graduate science courses. Although these questions cannot be considered a complete listing of all instructor-initiated questions in the fifteen courses, they represent a majority of all instructor-initiated questions.

When categorized according to the Wilen hybrid question classification levels (Wilen, 1991), 4.8% were low-convergent, 43.5% were high-convergent, 28.7% were low-divergent and 23% were high-divergent questions. Although the majority of the questions were classified at the Level II or high-convergent level of questions, it is

interesting to note that when grouped into two levels of convergent (low-cognitive) and divergent (high-cognitive) questions, the largest percentage (51.7%) of instructor-initiated questions occurred at the divergent level. Although this is what might be anticipated in graduate courses, it is inconsistent with that found in the literature on levels of instructor-initiated questions in traditional instructional settings. As described in Chapter 2, the literature has changed very little over the past thirty years. It has consistently indicated that instructors ask a majority of questions at the low-cognitive or convergent level and ask very few questions at the divergent or high-cognitive level.

The fact that NTEN instructors used a majority of divergent questions in their online instruction is a positive, but perhaps not surprising, outcome. The courses were offered in a mature program with a well-defined audience and clear goals. Faculty teaching these courses were experienced in both graduate and online instruction. In addition they have had the opportunity to share their online teaching experiences with peers as part of faculty development efforts encouraged by the NTEN program. They were also provided information regarding the background, needs, and experiences of their students. NTEN project evaluation reports indicate that students are engaged and satisfied with the online interaction, indicating that instructional techniques used by NTEN faculty engaged students in more than rote or comprehension levels of dialogue.

Formulating good questions is an important skill and teachers can facilitate its mastery by modeling good questions in the classroom. Faculty development in the NTEN program has promoted modeling of hands-on active learning in the science classroom. Faculty were made aware that teachers teach the way they were taught, and

that modeling instructional techniques for use in their own science classrooms is an important attribute of the NTEN program. The fact that faculty in this study used higher-cognitive levels of questioning is an important modeling activity and positive comment on the instruction in the program.

The distribution of question levels within individual courses indicates that instructors used a variety of levels of questioning in many of the courses. This again is a positive commentary on the instruction in this sample of courses. The value of using a variety of questioning levels to enhance instruction is supported in the literature (Wilén, 1991). The cognitive levels of instructor-initiated questions in these courses appear to differ from those typically described in the literature, which indicates that the majority of instructors asked questions primarily at the convergent level. The instructors appear to have utilized a variety of question levels, the majority being divergent questions, in their attempt to engage students in online discussion. Although this use of divergent or higher levels of questioning might be attributed to the graduate student audience, it is possible that the instructors adapted their instruction to meet the unique characteristics of the online environment, to engage students in collaborative and constructive learning, and to model good teaching techniques for this particular audience. Anecdotal and evaluation reports from courses in this study indicate that instructors have changed the way they teach as a result of the online classroom and its time-and-place independence. Instructors in the online courses cannot rely on the traditional lecture/recitation pattern as a teaching model in this environment. Further research to examine the possible increase in the use of

divergent questions to stimulate discussion and learning as a teaching technique that occurs as a natural adaptation to the online classroom may be useful.

Question Levels and Course Discipline: In order to better understand the use of various question levels within the sample of courses, the frequency of question levels were determined for each of the three course disciplines. All courses used in this study were grouped into the three disciplines of biology (five courses), physics (four courses), and earth science (six courses). The majority of questions were asked in biology courses (52.6%), followed by earth science and physics respectively. A majority of questions in biology courses were at Level II (high-convergent) with the remaining questions spread equally between Level III and Level IV. Earth science courses showed a very similar pattern. Questions in physics courses, however, were distributed almost equally between Levels II, III and IV and showed a higher percentage of Level I questions than the other two disciplines. A comparison of means using a one-way ANOVA showed no significant difference in the mean level of question asked in each of the three disciplines.

The distribution of question levels in each of the disciplines may be attributed to traditional methods of teaching in each of these disciplines. Biology and earth science, both of which may be considered less quantifiable disciplines than physics, may traditionally use question and discussion as a teaching technique more than physics. Physics, which involves more use of equations and mathematical problem solving, may traditionally utilize more Level I questions to solve equations and then make use of higher-cognitive levels of questions to apply this information.

Question Levels and Time In Course: There were no statistically significant differences found in the cognitive level of instructor-initiated questions recorded during early, middle, or late time periods in the courses studied. It was expected that question Levels III and IV, which require higher levels of cognitive thought, would increase during the last third of the course as course content complexity and instructor expectations of student knowledge increased.

Although this result was not anticipated, it may be a function of the graduate audience. Based on prerequisites and an understanding of the student population, instructors may not have felt a need to start the instructional process with lower-level questioning. This result might also be attributed to the course design and the electronic asynchronous environment. Questioning appears to be used by instructors primarily as a tool to engage students in online interaction. This would necessitate the use of more than rote or convergent questions, regardless of what point in the course.

#### Conclusions Regarding Interaction Indices

Research Question #2: What student-student and student-instructor response patterns occur as a result of specific cognitive levels of questions? Overall, the number of students participating in the discussion and posting responses to questions in the courses was relatively high, with an average of 58% of students participating in responses to instructor-initiated questions. Results of the supplemental course review indicated that instructors emphasized online discussion and participation. In addition,

results of the study indicated that the use of higher cognitive levels of questions may be an effective tool for increasing individual student participation in discussion.

Discussion diagrams and the calculated interaction indices in this study indicate that only a small amount of the total interaction that was possible was realized. At first glance it might appear that students were interacting more with the instructor than with fellow students. Further examination of the results, however, reveal that this is not the case and indicate that actual interactions between students and between instructor and student were roughly comparable in volume.

The normalizing function of the total-interaction, instructor-mediated interaction, and the instructor-independent interaction potential calculation, creates a tendency for the instructor-mediated interaction score to be much greater than either the total-interaction, or instructor-independent score. This may create an artificial impression regarding the low volume of student-student interaction in the discussions reviewed in this study. In order to better understand the results, comparisons were made between the instructor-independent index and total-interaction index, which are both similar in their normalizing function. Although these results vary considerably by course, the average across all courses is .101 for total-interaction, and .058 for instructor-independent interaction. Comparison of these mean indices show that only .043 of the total interactions involved a student and instructor, indicating that students were more likely to interact with another student than with the instructor as a result of instructor-mediated questions.

There are several other factors that must be considered. The instructor-independent interaction potential (which represents the amount of student-student

interaction compared to the amount possible) is calculated based on the total number of connections that could *possibly* be made between students in the course. In cases where the class enrollment is relatively high (25 students), the number of potential connections is quite large,  $[25 \times (25-1)]/2$ , and the formula assumes that each student could interact with each of the other students in the class at least once for each question. That may be an unrealistic expectation based on the number of students in the class and the difficulty, even in the traditional classroom, in engaging every student in class in some form of discourse.

In addition, interaction as a result of instructor-initiated questions is not the only place where student-student interaction occurred throughout the course, and it should not be assumed that the study findings represent the total amount of student-student interaction in the course. Most of the NTEN course instructors provided a "coffee house" conference area in which students were encouraged to carry-on discussions that might not pertain to a given assignment or course topic. There were also many opportunities for students to initiate questions and these questions and the resulting dialogue were not analyzed as part of this study. Further research regarding student-student interaction that occurs independent of instructor-initiated questions would provide valuable insight regarding student-student interaction in online instruction.

Interaction Indices and Course Discipline: Comparison of interaction indices across the three course disciplines of physics, earth science, and biology revealed some interesting differences in interaction patterns between the three course disciplines. The total student participation mean index was higher in both biology and earth science

courses indicating that a greater percentage of students participated in discussions in these disciplines than in the physics courses. Similarly, the total interaction potential index, instructor-mediated interaction potential index, and instructor-independent interaction potential index all appeared to be considerably higher in biology and earth science than in the physics courses. The indices show that overall interaction resulting from instructor-initiated questions in the four areas measured was higher in both earth science and biology than in physics.

Bickel (1999) conducted a mini-case study discussion diagram analysis that compared interaction indices between sample discussions in three NTEN courses in the disciplines of physics, education, and biology. Although education pedagogy courses were deliberately eliminated from this study in order to reduce comparisons across very different instructional disciplines, it is interesting to note several similarities to Bickel's findings. Both the biology and education course in Bickel's case study showed more total student participation and student-directed (instructor-independent) interaction than the physics course. Similar results were found in this study, with both earth science and biology showing larger total student participation and instructor-independent interaction than the physics courses. Bickel's physics course discussion showed a greater mix or combination of exchanges, both among participants (instructor-independent) and between students and instructors (instructor-mediated) when compared with biology, which was predominantly instructor-mediated. Similar results were observed in this study. On average, a greater combination of exchanges occurred in physics courses than were found in either biology or earth science courses.

Bickel (1999, p. 35) concluded that the level of interaction was not necessarily determined by course content and that "it is likely that the differences in the on-line environments were influenced by differences in course design." The supplemental course review supports this conclusion.

### Conclusions Regarding the Relationship Of Question Level and Response Patterns

Research Question #3: Is there a relationship between the cognitive levels of instructor-initiated questions and the resulting student-student and student-instructor interaction patterns in the NTEN courses? Analysis of interaction indice means for each of the four question levels showed a significant difference ( $p < .05$ ) between cognitive levels of questions and the indices for total student participation and instructor-mediated interaction. Significant differences occurred between Level I (low-convergent questions) and the remaining three levels. Higher cognitive levels of questions (II, III, IV) resulted in an increased percentage of individual students who responded to a given question, and resulted in an increased chance that an instructor would connect with each individual student in the course in response to the question. This finding was anticipated based on both the literature review and anecdotal information from the post-course evaluations. Questions asked at increasing levels of cognitive ability would be expected to increase the percentage of total students participating in the responses (Wilén, 1991). Questions at higher cognitive levels, involving answers that require more than rote memorization, should also have a higher percentage of individual student-instructor connections when compared with the total possible number of instructor-student connections. This is

consistent with NTEN evaluation reports in which instructors perceive large volumes of interaction with students, and students indicate that online interactions with the instructor helped them learn both the course content and how to apply it in their own teaching.

There appeared to be no relationship between the cognitive level of questioning and the amount of individual student-student connections. Nor did there appear to be a relationship between question level and the total interaction potential, or the likelihood that all students would interact with one another and with the instructor in the discussion. There was no statistically significant difference between the cognitive level of questions and the indices for instructor-independent interaction potential or total interaction potential. This was not anticipated. Although the NTEN courses used in this study show that the instructors used a higher percentage of Level III and IV questions than found in the traditional classroom literature, the use of higher-level questions did not result in a significant increase in the total interaction index, nor did it increase the student-student interaction index.

#### Conclusions from the Supplemental Course Reviews

In order to identify course design factors that might contribute to overall student-student interaction, supplemental course reviews were conducted on the courses from each discipline that had the highest mean index for instructor-independent interaction.

Overall, there were more similarities than differences in the design of these three courses. In each course the students were provided with clear course goals and expectations, detailed assignments and well-defined schedules and deadlines. Two of the three courses provided students with regular progress reports regarding point status and

projected grades. All three courses emphasized online discussion and based 40% or more of the final grade on participation in discussion. Courses varied in whether or not the discussion-participation grade was based on quality of the posted comments or simply on participation.

The three course instructors were overwhelmingly supportive and positive in their interactions with students and the class in general. Students were encouraged to ask questions, to interact with both the instructor and fellow classmates, and to take responsibility for their own learning.

Courses varied considerably in the frequency of instructor-initiated questions. This can be attributed to course design and the level of responsibility placed on the students for generating discussion. In the physics course, for example, students were required to post the weekly discussion topic, resulting in very few instructor-initiated questions when compared to the biology and earth science course. Both the earth science and biology course were more "instructor-led" and encouraged student participation in the discussion itself. Students were required to post a response to the weekly instructor-initiated discussion and to respond to another student's comment.

In the biology course the emphasis on participation went one step further when the instructor asked students to end their responses to the instructor-initiated question with a new question. Each student had to respond to the previous student's question and post his or her response to the original instructor-initiated question. This instructional technique would account for the relatively high score on the instructor-independent interaction index in this particular course.

Another variation in the courses was the use of small groups for discussion. Both earth science and biology instructors assigned students to small discussion groups for many of the instructor-initiated questions. Physics questions were all asked of the entire class. In this mini-case study, it appears that small discussion groups might have encouraged increased student participation, as the earth science and biology courses both had a total participation potential index over twice as high (91%), as the physics course (44%).

Student comments in the post-course evaluations contained an interesting mix of comments that described the online discussions and interaction with peers and instructor as both a strength and weakness of the course. Several students commented on the value of sharing ideas, collaborating on assignments, and learning from others. Negative comments regarding the online discussions were most likely a reflection of students' expectations or desire for a traditional classroom environment in which the instructor lectures or provides students with content in a more directed fashion.

Courses with higher interaction indices for student-student interaction consistently had the following course design factors: clarity of goals, student and instructor expectations, schedules and assignments, grading, overall electronic classroom organization, emphasis on participation in online discussions, and sensitivity to needs of the participants. These results are consistent with what was found in the literature. Courses with higher interaction indices for student-student interaction differed in the amount of instructor involvement in initiating questions and discussion topics, and in the level of responsibility placed on the students for initiating content discussions. They also

differed in the instructor's use of instructional techniques such as small study groups, collaborative assignments, and more detailed requirements for the discussion response format.

### Conclusions Regarding Post-Course Evaluation Data

A review of the evaluation data revealed that a majority of students in these particular courses "agreed" or "agreed strongly" that interactions with both the instructor and with other students helped them understand the course content. The majority of students also indicated that they would recommend the course to their peers. Post-course evaluations consistently resulted in high levels of agreement with the statement "interaction with fellow students helped me understand the content better."

When evaluation data were compared by disciplines, the physics courses had the highest means for students' agreeing that interactions with the instructor and other students helped them understand the course content, followed by biology and earth science respectively. These results are somewhat surprising when compared with the instructor-mediated and instructor-independent interaction indices. When interaction indices and post-course evaluations were compared by discipline, courses that showed the highest scores—for perceiving that interaction with the instructor and other students helped them learn the content—were also those courses that actually engaged in the smallest proportions of student-student and student-instructor interaction potentials in discussions resulting from instructor-initiated questions.

There may be several explanations for this phenomenon. It is possible that a large percentage of the total student-student interaction in the courses occurred independently

of instructor-initiated questions. Many instructors encouraged students to initiate questions or discussion topics and to respond to other students in the electronic classroom. In several of the physics courses, for example, students were required to post weekly "reading memos" to another student and to post a response in return. The facilitation of this kind of interaction is an example of a teaching technique that might be more difficult to accomplish in the traditional classroom. Also most instructors facilitate the use of a "coffee house" conference area in the course and encourage students to use this area to engage in discussion that is not related to specific course assignments or topics. It is also possible that student-student interaction related to specific questioning was missed in the study due to the limitations of the software "thread" function described in Chapter 4.

This study did not take into account the use of personal interaction or private e-mail between students. Records of private e-mail messages between students or between students and instructors are not maintained by the software or the NTEN project for reasons of individual privacy. Further, research regarding student-student interactions occurring independent of instructor-initiated questions in online instruction would provide additional insight.

Another interesting possibility is the notion that student evaluations are a reflection of perceived value from interactions in which they participate vicariously. Literature in online instruction often supports the value of "lurking" in electronic discussions, a practice that allows students to observe interaction without actually participating (Hiltz, 1994; Harasim, 1990b). It may be possible that student evaluation data indicate that just

*observing* the interaction between student-student and instructor-student was perceived to be as valuable as actually participating in the interaction.

As described earlier, this discrepancy may also be a function of the normalizing calculation for the interaction indices. The fact that, on the average, over 50% of the total interaction occurred between students would account for students perception regarding the value of interactions with their online peers.

### Discussion of Conclusions as They Relate to the Literature

#### Instructor-Initiated Questions in Online Instruction

As early as 1860, Ross (1860) suggested that the two purposes of questioning in instruction are to 1) ascertain whether students remember what is taught and 2) have students apply what they have learned. Stimulating interest and discussion, involving students in creative thinking, and arousing student interest are all cited as ancillary purposes of questioning (Ross, 1860). Wilen (1991) noted that a review of the literature on questioning shows that most teachers continue to use a majority of low-cognitive questions in the traditional classroom in order to assess recall of knowledge. Questioning at higher cognitive levels may become more pivotal to the instructional format in the online, asynchronous, teaching/learning environment. In an attempt to adapt to an instructional setting with a limited ability to accommodate the traditional lecture format, instructors may find themselves using questioning as an integral course design component. Instructors in this study appeared to use high-cognitive levels of questions more for engaging students in the process of constructing content knowledge and the

application of that learning, and less for assessment of students' comprehension of broadcast lecture material. One very positive result of this adaptation may be the increased instructor use of higher cognitive levels of questions, which require students to reflect on and assimilate knowledge, rather than simple rote recall of information.

NTEN post-course evaluation interviews with instructors indicated an emerging theme: instructors realized that teaching on-line draws on a different set of skills than they are accustomed to using in their traditional teaching and that they are placing increased emphasis on discussion (Smith, 1999). The following quotations reflect this theme:

If you are teaching materials that the teachers don't know, but really want to know like meteorology or quantum physics, or something they don't know much about, then the online course is going to be a really rich experience because they're going to get to see the new material, mull it over, talk about it with each other, and your job as an instructor is to keep the conversation going literally by never giving an answer. Just by prodding it along. I convinced myself that I could send an e-mail message into a discussion and sort of disguise it as a question and maybe keep the discussion going, and the answer is no. As soon as you put your name in there, it dies. Because you are the authority and people stop speculating, even if you try to mask your note in context of another question. (new instructor)

Pontificating kills those discussion items, so even though I tell too much, I try to tell it briefly. That's the hardest part of the discussion is not giving the answers. When I log on in the morning, I go through and say to myself, 'Is this discussion going in the right direction? Will someone chip in with something useful next?' And if the answer is yes, or probably yes, I let it go. (veteran instructor)

The three most experienced instructors described themselves as primarily lecturers in their on-campus teaching, and each had come to the conclusion through trial and error that discussions must be the dominant whole-class pedagogy in on-line courses...yet each had a slightly different approach to discussions, varying in the amount of control they retain. (Smith, 1999, p. 13-14)

The frequency of higher cognitive levels of questions used by instructors in the courses in this study is encouraging, however, this finding cannot be assumed to exist within the general population of instructor-initiated questions used in online instruction. NTEN is a mature, online program of graduate courses with a reputation for its emphasis on the importance of the online discussion in the course design (Smith, 1999). Faculty comments indicated that the instructors believe that they have changed their teaching styles as a result of the asynchronous and online nature of the course delivery, and this may account for the increased use of higher cognitive levels of questions as compared to the question-level use described in traditional classroom literature. In addition, faculty participated in faculty development sessions, share their course design and experiences with other faculty, and observe one another's online courses. This modeling may promote the higher levels of cognitive questions used by experienced faculty. From its inception, NTEN was committed to inquiry-based, hands-on, and active learning techniques. Faculty were encouraged to model these instructional techniques with the belief that the course participants (pre-college teachers) would then be more likely to model them with their own students.

#### Student-Instructor Interaction Patterns

In this study, the higher cognitive levels of instructor-initiated questions reflected a significant difference in the total student participation index. Instructor use of higher cognitive levels of questions should, therefore, increase the probability that a greater percentage of participants in a course will engage in and contribute to the discussion. Just

as some students are reluctant to participate in a traditional classroom discussion, some students find it difficult to post comments and engage in the asynchronous discussion in a computer-mediated conferencing environment. Although individual learning styles and personality differences play a strong role in the willingness of students to engage in discussion, it is important in any instructional medium to optimize the chances for engaging more students in content discussions. The instructor's use of higher cognitive levels of questions appears to encourage more students to respond to questions in the computer-mediated conferencing classroom and should be encouraged.

Higher cognitive levels of questions also showed a significant difference in the instructor-mediated interaction potential index, indicating that there was an increase in the overall number of connections between instructors and students when compared to the number possible in any given discussion. This again, may be considered a desirable outcome in the computer-mediated conference classroom. Increasing levels of interaction between an instructor and each individual student enhances the instructor's ability to establish a personal connection and rapport with each student. It also increases the quantity of dialogue that other students are able to observe and benefit from, even though it might not involve their actual participation.

There are also negative connotations to an increase in the quantity of student-instructor interactions. Bichelmeyer and Kiggin's (1998) study of web-based instruction concluded that the major disadvantage noted by faculty was the amount of time involved in teaching using this medium. Increased individual student contact increases the amount of time that an instructor has to spend on the course, and has implications for class-size

scaling issues in distance learning. If the majority of online interactions take place between instructor and student, any attempt to increase the number of students in the course will continue to be problematic. Instructors in a traditional higher-education environment cannot provide quality individualized instruction in online course sections with large numbers of students if all interaction is conducted one-on-one with each student. This high quantity of individual instructor-student interaction also has the potential to result primarily in a recitation pattern of discourse, similar to what is most often found in the traditional classroom. This recitation pattern occurs when an instructor asks a question and each student responds individually and directly to the instructor. There are indications that instructional style and course design factors may have a greater influence on the instructor-mediated and instructor-independent interaction potential index than the particular level of question; however, this cannot be determined from this study and is worthy of further research.

#### Student-Student Interaction Patterns

Although it was predicted that the potential for student-student interaction (instructor-independent index) would increase as a result of higher cognitive levels of questions, there was no significant difference between the levels of questions and the results of the instructor-independent interaction index. Visual examination of the discussion diagrams and the interaction index analyses indicate that although the amount of interaction was low compared with the total amount of interaction that was possible, students were more than 50% likely to interact with other students as with the instructor. The fact that interaction between students and between instructor and student were

roughly comparable might indicate that the interaction pattern in these online courses might be different from the traditional classroom recitation pattern found in the literature. Dillon (as cited in Wilen, 1991) and Wilen (1991) concluded that although most teachers define any form of interaction as "discussion," the majority of interaction in the traditional classroom is primarily a recitation form of discourse. Shearer (1998) found similar results in the computer-mediated conferencing environment, reporting that the majority of students did not read the responses of other students before posting their own comments. Berge (1997b) concluded that instructors' apparent use of student-focused methods of instruction in online course delivery, does not guarantee the desired student-focused outcomes.

The importance of peer interaction is documented in the literature (Harasim, 1989) and this study provides a benchmark comparison between the amount of student-instructor interaction compared with student-student interaction in response to instructor-initiated questions in online instruction.

Harasim (1990b) noted that educational research has identified peer interaction among students as a critical variable in learning and cognitive development at all educational levels. According to Harasim (1990b), peer interaction has been linked to an increase in motivation and satisfaction, as well as to a reduction in uncertainty and anxiety—factors that contribute both to a learner's capacity to understand new concepts and to increased engagement in the learning process. She noted that the computer-mediated conferencing environment is ideal for supporting cooperative and collaborative

learning that encourages students to seek interactions with their peers and other resources beyond those provided by the instructor.

The amount of student-student interaction, as well as the students' post-course evaluation perceptions regarding the value of interaction, may have important implications for course design in online instructional settings. Students indicated that they perceived value from interactions with their peers in understanding course content, however the actual amount of student-student interaction is very low compared with the amount that was possible. Instructors and instructional designers of online courses need a better understanding of how students define valuable interaction with their peers, what kinds of interactions contribute to the learning process, and what design factors contribute to promoting the maximum amount of useful interaction that is possible.

The comparisons of actual interaction, perceived value of interaction, and the total interaction possible indicates that it may be difficult for instructors to gauge the actual types and amount of connections that occur during a course. As mentioned earlier, it is relatively easy for an instructor to observe interactions occurring between students in a traditional face-to-face classroom. It is not as easy to visualize this in the computer-mediated conferencing environment. Even though the comments are threaded and posted for everyone to read, the big picture and patterns of connectivity may not be obvious. Quantity of messages and the volume of instructor-student connections may create an optimistic impression of the amount of interaction.

### Differences in Content Discipline

The results of this study showed no significant difference in the cognitive levels of questions asked in each of three course disciplines. However, there was a significant difference in the means of the four interaction indices for the three disciplines. The differences found, were primarily between the physics courses and the other two disciplines of earth science and biology.

In commenting on the challenges of classifying and analyzing questions, Wragg (1984) noted that systems of analyzing questions and their meaning are inevitably modified by the context and intensions of teachers and students. Some of the differences in question levels and interaction indices identified in this study may be attributed to traditional instructional styles in each of these disciplines. However, the results of the supplemental course review, as well as comparisons with the post-course evaluation results, indicate that this difference was more a result of course design factors in the courses, than a result of the discipline.

### Differences in Course Design Factors

The supplemental course review identified course design factors that are consistent with the literature regarding successful online teaching and learning (Berge, 1997a; Cyr 1997). Each of the three courses reviewed were found to be highly organized, in the expectations, assignments, grading policies, and communication with the students, and in the physical organization of the electronic classroom. Instructors were positive, energetic, enthusiastic about the content, and indicated a desire to meet the needs of individual students. All three courses recorded a large number of online public

interactions independent of instructor-initiated questions. In addition, they received high marks from students regarding the value of student and instructor interactions, and overall course satisfaction reported in the post-course evaluations.

Several course design factors could account for the differences in the number of instructor-initiated questions and differences in student-student interaction indices between disciplines. The physics course relied primarily on student-initiated content questions for weekly discussions. Students were put in the role of instructor and were given primary responsibility for initiating and moderating the content discussions in the course. Student-student connections that existed independent of instructor-initiated questions were not analyzed in this study. Both the biology and the earth science courses relied on instructor-initiated questions; however, small study groups of seven or fewer students were expected to discuss the questions within their group. Several students commented that this gave them the opportunity to interact with a greater variety of students in the course. In addition, the biology course required students to post additional questions as part of their original response and to respond to other students' questions in the same discussion. Only one course (physics) showed a relatively equal mix of instructor-initiated questions from across the four levels. Both the earth science and biology courses had a majority of questions at Level II, the high-cognitive level. According to the literature reviewed, the use of questions across a variety of cognitive levels is not well researched (Gall and Rhody, 1987), and Konya (1972) concluded that students responded more often with higher levels of thinking when teachers asked an equal amount of high and low-cognitive questions. Further study regarding the use of a

variety of cognitive levels of questioning and the resulting student interaction patterns and types of responses would be valuable.

### Perception Versus Reality in Interaction Patterns

The use of interaction indices, evaluation data, and supplemental course reviews offered three very different perspectives from which to examine the course sample. Interaction index analyses provided quantitative results that establish a baseline regarding cognitive levels of questions and the resulting amount of student-student and student instructor-interaction. These analyses also quantify the amount of interaction in comparison to the amount that could actually take place.

The quantitative results of the discussion diagrams and the calculated interaction indices might indicate that relatively little communication was taking place between students in this study. As described earlier, this may be a function of the impact of normalizing when the interaction indices are calculated. Comparisons of total-interaction and instructor-independent indices indicate that on an average, 50% or more of the total connections in each discussion occurred between students. The fact that 50% or more of the total connections were occurring between students, offers a plausible explanation for the students' and instructors' perception regarding volume and value of interaction. In spite of the low total interaction and instructor-independent interaction indices, it may be that the actual student-student interaction in courses in this study was equal to or greater than what typically occurs in a traditional classroom discussion.

Examination of the post-course evaluation data confirmed that students in the courses in this study perceived that interaction with fellow students and with the

instructor was valuable in helping them understand the course content. Courses with the highest average score for perceived value in student-student and student instructor interaction showed the lowest mean score on all interaction indices. This discrepancy indicated that the interaction potential indices may not be reflective of actual interaction or the value perceived by the students. It also indicated that valued interaction may be occurring independent of instructor-initiated questions through lurking and observations of other students' interactions.

Finally, results of the supplemental course reviews were consistent with the literature regarding course design techniques for promoting online student interaction and satisfaction. The reviews also offered insight regarding the interaction index results in various course disciplines and indicated that the differences may be due more to elements of course design than to content discipline.

It appears, from the results of this study, that although higher cognitive levels of questions promote student participation and instructor-mediated interaction, the use of higher cognitive levels of questioning alone was not sufficient for promoting interaction among and between students in online instruction. It may be more difficult to facilitate effective reflective discussion with the use of high-level questions in the online environment and it may be that other course design factors must be considered in order to promote peer interaction in the discussion.

Further research is necessary to understand when, where, and why communications take place between and among students in the online courses. Are students interacting with one another regarding course content in discussion areas

independent from instructor-initiated questions? Are students interacting primarily through private email? Are student interactions related to course content? Is the perceived value of the interaction related to understanding of course content or to the existence of a support network and the ability to “lurk” or observe the interactions between others? How do we help instructors do things that generate successful discussion and dialogue in online instruction?

It would also be valuable to further examine the use of discussion diagrams or other tools that enable instructors to visualize the patterns of interaction that occur throughout the course while it is being taught. Quantity of messages and the asynchronous text-based environment make it difficult for instructors to establish a “big picture” perspective of the online classroom environment. Tools such as discussion diagrams may provide instructors with valuable information, not only regarding the quantity of interactions, but regarding the specific types and patterns of interactions and connections between students. Discussion diagrams might allow an instructor to identify the existence of recitation versus dialogue types of interaction, students who might seldom contribute to or dominate discussion, and instructional activities that result in increased interaction between students. This information will be important as educators strive to understand ways to effectively design and facilitate collaborative and constructive electronic learning environments.

## Implications

### Implications for Theory

This was a descriptive study using existing data from course transcripts and post-course evaluations from a sample of online courses. Consequently, it was not designed to test any existing educational theories. There are, however, some implications for the current understanding regarding the use of computer-mediated conferencing to facilitate learning.

The literature indicates that the majority of practitioners involved in online instruction using computer-mediated conferencing subscribe to the social constructivist theory of learning (Kanuka & Anderson, 1998; Driscoll, 1994; Anderson, 1996). This social constructivist philosophy in online instruction is based on the belief that knowledge is created through social intercourse and that it is through this interaction that students gradually accumulate advances in understanding (Kanuka & Anderson, 1998). The high percentage of high-level cognitive questions found in the sample of courses might indicate that some faculty teaching courses analyzed in this study subscribe to this theory as well. Students were encouraged to share and incorporate their own experiences and knowledge in the online discussions, as well as to apply the content to their classroom teaching; and the instructor-initiated questions indicated an attempt to facilitate this constructivist theory of learning. Although the results show that the student-student interaction may be low when compared with the total possible number of interactions, they also show that given an instructor-initiated question, students in this study were equally likely to interact with a fellow student as they were with the instructor.

Further research is necessary to understand the role of actual, as well as virtual, student-student interaction in the online environment. Research to identify course design factors that promote the type of student-student interaction that results in the construction of knowledge and learning in the electronic classroom will be critical to the future success of this medium as a teaching/learning environment.

### Implications for Practice

This study was not designed to establish any cause-effect relationship between the use of various cognitive levels of instructor-initiated questions and the online interactions between students and instructors. It does, however, offer potential insights into the cognitive levels of questions asked by instructors using computer-mediated conferencing for course delivery and into the nature of online discussions in general.

1. The use of higher cognitive levels of questions appear to increase both the likelihood that more students will participate in the online discussion, and the chances that an instructor will interact with each individual student in the course sample. Questions that require students to apply, synthesize, or evaluate information—and that encourage them to incorporate the new knowledge into applications relevant to them—might better enable instructors to engage students in online discussion and facilitate ongoing instructor-student dialogue.
2. Findings in this study are consistent with the literature reviewed that indicated that instructor organization and effective discussion-facilitation skills to be key components for a successful online course (Jiang, 1998; Berge, 1997a, 1997b; Harasim, 1995). Course organization, instructional design, and effective facilitation

for online discussion, are all important factors in a student's perception of what makes a successful online course and may positively influence the amount of student involvement and student-student interaction that occurs.

3. Online interactions and discussions may benefit from a more systematic design and mix of levels of instructor-initiated questions. Although this study did not attempt to assess instructor motivation or level of intentional instructional design in the use of questions, cognitive levels of instructor-initiated questions appear to be more dependent on the individual instructor's personality and style than on any systematic plan for deploying specific levels of questions. Although the lecture format was minimized in the courses in this study, the results show that the majority of the courses in the sample were still "instructor-led" in their online discussions. Instructors using computer-mediated conferencing for distance course delivery may want to consider increasing student responsibility for initiating questions and discussion topics, putting students in the role of instructor, and facilitating increased opportunities for interaction between students.
4. Appearances regarding the quantity and patterns of discussion in computer-mediated conferencing may be deceiving. Given the asynchronous and text-based nature of the computer-mediated conferencing environment, it may be difficult for an instructor to effectively assess the level and patterns of participation by various students, particularly in courses that never meet face-to-face. Tools such as discussion diagrams, which allow an instructor to visualize and/or quantify the patterns of various kinds of interaction, would be valuable for instructors to better understand

the big picture of the discussion environment as it is occurring. Non-participation and lack of student-student interaction does not necessarily indicate that learning is not taking place. However, finding ways to facilitate student-student discussion, as opposed to recitation, in the online classroom will be critical for creating truly effective asynchronous learning environments.

5. The use of higher cognitive levels of questions may be encouraged by faculty development that provides faculty with the opportunity to observe other online courses and faculty. Faculty for courses in this study were provided with a variety of development opportunities, including workshops presented by experienced faculty, one-on-one mentoring, online course observation, and written materials from past courses and program evaluations. Palloff and Pratt (1999) noted that both faculty and students learn to ask "expansive" and higher level questions through modeling the behavior of others. Further research is necessary to determine if there is a relationship between the cognitive level of instructor-initiated questions and both student- initiated questions and the cognitive level of response.

### Implications for Research

This study was an attempt to begin to identify questions and issues surrounding the use of instructor-initiated questions at various cognitive levels and the resulting patterns of student and instructor interaction in instruction using computer-mediated conferencing. This study contributes to future research in three ways. First, it begins to identify the cognitive levels of instructor-initiated questions used in online instruction facilitated by computer-mediated conferencing. These results may indicate that the use of

higher cognitive levels of questions is occurring in larger numbers in online instruction, than in traditional classroom instruction. This may occur online as a result of encouraging student discussions in place of the traditional lecture broadcast medium.

Second, the study establishes a benchmark for the types of instructor and student-interaction patterns that occur as a result of various levels of instructor-initiated questions. Results of the study indicate that higher cognitive levels of questioning may be a valuable instructional technique for promoting increased student participation. It may also increase the probability that an instructor will interact with a greater percentage of individual students in the discussions. Results also show that students interacted with fellow students equally or more often than they interacted with the instructor as a result of the instructor-initiated questions.

All popular press reports and population demographics point towards an increasing client demand for anytime, anywhere learning, and to a rapid shift in higher-education distance learning efforts to meet that demand. Understanding how questioning at various levels might be used to facilitate constructive, collaborative learning environments, as well as how to facilitate effective student-student interaction in order to scale online courses for increasing student enrollments and still keep instructor time manageable, will continue to be an important area of research.

The final contribution of this study can be found in the examination of discussion diagrams as an instructional tool in online teaching and learning. The value of quantity versus quality of discussion and the necessity for promoting interaction among and between students is not well understood. Instructors need tools that will enable them to

better visualize the patterns of interaction that occur in the online discussions, as well as a better understanding of course design factors that might engage students in actual online discussion rather than recitation forms of discourse.

Findings from this study point toward several directions for future research.

#### Peer Interaction In Computer-Mediated Conferencing

1. What types of interaction in computer-mediated conferencing are most effective in contributing to the knowledge construction process and how can this type of interaction be facilitated? Wagner (1994) suggested that interaction in computer-mediated-conferencing should be analyzed by outcomes as opposed to agents (individuals with whom the interaction occurs). Quantifying the types of outcomes that occur and assessing whether these outcomes are a result of instructor-student or student-student interaction might further our understanding of learning in an online environment. The discussion diagram technique could be used to analyze types of outcomes, as well as individual connections that result from the various levels of questions or other instructional techniques.
2. What course design factors best facilitate and promote increased interaction between students?

#### Questioning In The Online Classroom

1. What is the relationship between cognitive levels of questions and the interaction patterns in discussions that are generated by student-initiated questions?

2. What cognitive levels of questions are generated by students in online courses, and is there a relationship between the levels of questions used by instructors and the levels of questions used by students?
3. What cognitive levels of questions are used in undergraduate online instruction?
4. Is there a relationship between the cognitive level of the instructor-initiated questions and the cognitive level of thought in student responses?

#### Perception Versus Reality in Online Course Interactions

1. What discrepancies exist between students' and instructors' perceptions of online interaction and what is actually occurring in the online activity?
2. How can tools such as the discussion diagrams be used to help instructors visualize and quantify patterns of online interaction? Discussion diagrams could be used as a tool for research into several of the questions listed above. The existence of detailed course transcripts in computer-mediated conferencing provides the researcher with an opportunity to analyze many aspects of the online course. Discussion diagrams might be used to compare cognitive levels of questions with the cognitive level of student responses, gender differences, roles of students experienced in online learning versus roles of students new to the medium, or student-student interaction that occurs independent of assignments or instructor-initiated questions. Discussion diagrams, or a similar visualization tool, could be especially valuable for enabling online instructors to assess the level and type of interaction occurring throughout the course, and allow instructors to make adjustments in instructional techniques that might encourage increased or broader participation and interaction among participants.

### Summary

The purpose of this study was to identify the cognitive level of instructor-initiated questions in a select group of online graduate science courses and to analyze the student-student and student-instructor interaction patterns that occurred as a result of various levels of questioning. The results of this study will be useful to the ongoing development of the National Teachers Enhancement Network Program, as well as to the overall body of educational research. The study results represent an initial attempt to describe the use of instructor-initiated questions in distance delivered courses using computer-mediated conferencing, and to quantify the types of interactions that occurred as a result of questions at various cognitive levels.

There are four primary conclusions drawn from the findings in this study: 1) The majority of instructor-initiated questions in the sample of courses were found to be higher-level cognitive questions, unlike results found in traditional classroom instruction; 2) Use of higher-level cognitive questions appeared to result in increased student participation and increased probability for student-instructor interaction in the sample of courses; 3) Students were equally or more likely to interact with a fellow student as with the instructor as a result of instructor-initiated questions; 4) Discussion diagrams provide a valuable tool for visualizing and quantifying the interaction patterns that occur in the online instructional process.

Implications of this study are consistent with Berge's (1997a) analysis that although we know that computer-mediated conferencing and online distance delivery can be an effective teaching/learning medium, we know very little about the course design

factors that contribute to the effective and efficient use of this medium. The findings imply that instructors used a larger number of higher-level questions in order to emphasize course discussion. This technique may be a result of an attempt to modify instructional style from a broadcast, instructor-led format, to an interactive environment in which students were encouraged to take more responsibility for learning. Results of the study also suggest that use of higher levels of questions alone was not sufficient for promoting student-student interaction. Further research is necessary to better understand the types and reasons for peer interaction in online learning, and course design factors that best facilitate student-student interaction that contributes to students' learning of course content.

Findings of the study show that although the total possible number of total interactions or student-student interactions is far from being realized, students were equally likely to talk with fellow students as they were with the instructor in content related discussions. Instructors and instructional designers need to better understand the quantity and types of interactions that are actually occurring in courses using computer-mediated conferencing for student and instructor interactions. Tools such as the discussion diagrams used in this study may be valuable for enabling instructors to both visualize and quantify the interactions as they occur throughout the course. Interaction visualization tools would enable instructors and students to make adaptations in course design and instructional techniques in order to provide greater opportunities for peer interaction and to establish a more constructive and collaborative learning environment.

## BIBLIOGRAPHY

Alavi, M., Yoo, Y., and Vogel, D. (1997). Using information technology to add value to management education. Academy of Management Journal, December v40 n6 p1310 (24).

Allen, B.S. (1992). Constructive criticism. Chapter 18 in T. Duffy and D. Jonassen (Eds.) Constructivism and the technology of instruction: A conversation. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Anderson, T. (1996). The virtual conference: Extending professional education in cyberspace. International Journal of Educational Telecommunications, 2 (2/3), 121-135.

Anderson, T. (1997). Online forums: New platforms for professional development and group collaboration. (ERIC Document Reproduction Service No. ED 418 693)

Anderson, T. and Kanuka, H. (1997). Evaluating the workplace center on-line forum: Knowledge construction and learning communities. Unpublished Research Report. Office of Learning Technologies. Human Resources, Canada.

Barnes, C.P. (1983). Questioning in college classrooms. In C.L. Ellner (Ed.), Studies of college teaching, 61-81.

Bednar, A.K., Cuninghan, D., Duffy, T.M., and Perry, J.D. (1992). Theory into practice: How do we link? Chapter 1 in T. Duffy and D. Jonassen (Eds). Constructivism and the technology of instruction: A conversation. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Berge, Z. (1992). The role of the moderator in a scholarly discussion group (SDG) [Online]. Available: <http://star.ucc.nau.edu/~mauri/moderate/>

Berge, Z. (1997a). Computer conferencing and the online classroom. International Journal of Educational Telecommunications, Vol. 3, No. 1, 1997.

Berge, Z. (1997b). Characteristics of online teaching in post-secondary, formal education. Educational Technology, 37 (3), 35-47.

Bettencourt, A. and Gallagher, J. (1980). Helping science teachers help science teachers: A study of change in junior high school science. Paper presented at the annual meeting of the National Association for Research in Science Teaching. San Francisco.

Bichelmeyer, B.A. and Kiggins, Elizabeth A. (1998). Using web-based conferencing in post-secondary instruction, 14<sup>th</sup> Annual Conference on Distance Teaching and Learning, (pp. 67-71). Madison: University of Wisconsin System.

Bickel, K., (1998). NTEN on-line interactions: A mini-case study using discussion diagrams. Horizon Research, Inc. Unpublished manuscript.

Bickel, K., (1999). Discussion diagrams: A method for illustrating and quantifying the interactive environment of discussion-based online courses. 15<sup>th</sup> Annual Conference on Distance Learning, Madison, WI August 1999. 29-37.

Bland, Kay P. (1992). Student attitudes toward learning link: A distance education project, Annual Meeting of the Mid-South Educational Research Association, 13p. Knoxville, TN. (ERIC Document Reproduction No. ED 356 766)

Bloom, B.S. (1956). Taxonomy of educational objectives. McKay, New York.

Bossert, S. (1988/1989). Cooperative activities in the classroom. Review of Research in Education 15: 225-52.

Bourne, J.R., McMaster, E., Rieger, J., and Campbell, J.O. (1997). Paradigms for online learning: A case study in the design and implementation of an asynchronous learning networks (ALN) course. ALN Journal. Available: <http://www.aln.org/alnweb/journal/issue2/assee.htm>.

Bouton, C., and Garth, R.Y. (1983). Learning in groups. New directions in teaching and learning, (No. 14). San Francisco: Jossey Bass.

Bradsheer, M. (2000). Personal communication. February 7, 2000, Washington, DC.

Bridges, D. (1990). "The Character of Discussion: A Focus on Students." In Teaching and Learning Through Discussion, edited by W.W. Wilen. Springfield, IL: Charles C. Thomas.

Brookfield, S.D. (1983). Adult learners, adult education, and the community. New York: Teachers College, Columbia University.

Brown, F.B. and Brown, Y. (1994). Distance education around the world. Chapter 1 in Barry Willis (Eds.) (1994). Distance Education: Strategies and Tools. Englewood Cliffs, NJ: Educational Technology Publications.

Caine, R., and Caine, G. (1991). Making connections: Teaching and the human brain. Alexandria, VA: Association for Supervision and Curriculum Development.

Clegg, A.A. Jr. (1971). "Classroom Questions." In The Encyclopedia of Education, edited by L. C. Deighton. Vol. 2. New York: Macmillan.

Collins, M.P. and Berge, Z.L. (1997). Moderating online electronic discussion groups. Paper presented at the American Educational Research Association Conference. Chicago: March, 24-28.

Collins, A., Brown, J.S., and Holum, A. (1991). Cognitive apprenticeship: Making thinking visible. American Educator, 15, 6-11, 38-46.

Cookson, P. (1999). Preparing for online teaching. Presentation at Montana State University-Bozeman. [Online]. Available: <http://btc.montana.edu/cookson/>

Crouch, J. (1998). The Effect of Parasocial Interaction, Traditional Interaction, and Perceptions about Learning on Question Forming in Distance Learning Classes. Master of Arts thesis, February 11, 1998, Regent University, College of Communication and the Arts.

Comstock, D. & Fox, S. (1996). Computer conferencing in a learning community. [Online]. Available: [www.seattleantioch.edu/virtualantiochcompon1.5.htm](http://www.seattleantioch.edu/virtualantiochcompon1.5.htm)

Cunningham, D.J. (1992). Assessing constructions and constructing assessments: A dialogue. Chapter 2 in T. Duffy and D. Jonassen (Eds.). Constructivism and the technology of instruction: A conversation. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Cyrs, T.E. (Ed.) (1997). Teaching and learning at a distance: What it takes to effectively design, deliver, and evaluate programs. New Directions for Teaching and Learning, 71, Fall. San Francisco: Jossey-Bass.

Davis, O.L.; Morse, K.R.; Robers, V.M.; and Tinsley, D.C. (1969). Studying the cognitive emphasis of teachers' classroom questions. Educational Leadership 26: 711.

Dede, C. (1996). The evolution of distance education: Emerging technologies and distributed learning. The American Journal of Distance Education, 10 (2), 4-36.

Dillon, J., ed. (1988). Questioning and discussion: A multidisciplinary study. Norwood, NJ: Ablex.

Driscoll, M.P. (1994). Psychology of learning for instruction. Toronto: Allyn and Bacon.

Duffy, T.M. and Bednar, A.K. (1992). Attempting to come to grips with alternative perspectives. Chapter 11 in T. Duffy and D. Jonassen (Eds.). Constructivism and the technology of instruction: A conversation. Hillsdale, New Jersey: Lawrence Erlbaum Assoc.

Duffy, T.M. & Jonassen, D.H. (1992). Constructivism: New implications for instructional technology. Chapter 1 in T. Duffy and D. Jonassen (Eds.). Constructivism and the technology of instruction: A conversation. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Eastmond, D.V. (1995). Alone but together: Adult distance study through computer conferencing. Cresskill, NJ: Hampton Press.

Eastmond, D.V. and Ziegahn, L. (1995). Instructional design for the online classroom. In Z. L. Berge and M.P. Collins (Eds.). Computer-mediated communication and online classroom: Vol. 3. Distance learning, (pp. 53-68). Cresskill, NJ: Hampton Press.

Edwards, A.D. and Westgate, D.P.G. (1986). Investigating classroom talk. Philadelphia: The Falmer Press.

Edwards, S. and Bowman, M. (1996). Promoting student learning through questioning: A study of classroom questions. Journal on Excellence in College Teaching, 7 (2), 3-24.

Eisenstadt, M. and Vincent, T. (1998). The knowledge web. London: Kogan Page.

Fabro, K.G. (1996). Computer conferencing in higher education: An exploration of communication and cognitive development issues (distance education). Unpublished MSC dissertation, University of Calgary (Canada). AAC MM18748. ProQuest-Dissertation Abstracts.

Fenwick, J. and McMillan, R. (1992). A question of questions. Paper presented at the World Conference of the International Council for Distance Education. (ERIC Document Reproduction No. ED 355 421)

Fosnot, C. (1992). Constructing constructivism. Chapter 16 in T. Duffy and D. Jonassen (Eds.). Constructivism and the technology of instruction: A conversation. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Foster, P.J. (1981). Clinical discussion groups: Verbal participation and outcomes. Journal of Medical Education, 56, 831-838.

Fulford, C.P. & Zhang, S. (1993). Perceptions of interaction: The critical predictor in distance education. The American Journal of Distance Education, 7, 8-20.

Galas, C., (1999). The never-ending story: Questioning strategies for the information Age. Learning and Leading with Technology, 26 (7), 10-13.

Gall, M.D. (1970). The use of questions in teaching. Review of Educational Research, 40, 707-21.

Gall, J.P., and Gall, M. D. (1990). "Outcomes of the Discussion Method." In Teaching and Learning Through Discussion, edited by W.W. Wilen. Springfield, IL: Charles C. Thomas Publisher.

Gall, M.D. and Rhody, T. (1987). Questions, questioning techniques, and effective teaching. ed William W. Wilen, Washington DC: National Education Association.

Gall, M. D.; Ward, B.; Berliner, D. C.; Cahen, L.; Crown, K.; Elashoff, J.; Stanton, G.; and Winne, P. (1975). The effects of teacher use of questioning techniques on student achievement and attitudes. San Francisco: Far West Laboratory for Educational Research and Development.

Gallagher, J.J. and Aschner, M.A. (1963). A preliminary report on analyses of classroom interaction. Merrill-Palmer Quarterly. 9 (3), 183-194.

Garrison, D.R. (1990). An analysis and evaluation of audio teleconferencing to facilitate education at a distance. The American Journal of Distance Education. 4, 13-24.

Gliessman, D. (1985). Questions in classrooms; questions in the lecture. Teaching and Learning at Indiana University Series, Indiana University, Bloomington.

Glossary of Distance Education and Internet Terms (1999). [Online] Available: [www.iteachnet.com/oct97/atriathy\\_oct97.html](http://www.iteachnet.com/oct97/atriathy_oct97.html)

Graesser, A.C., & Person, N.K. (1994). Question asking during tutoring. American Educational Research Journal, 31, 104-137.

Guilford, J.P. (1956). The structure of intellect. Psychological Bulletin. 53 (4), 267-292.

Gunawardena, C. N., Lowe, C. A., Anderson, T. (1997). Interaction analysis of a global on-line debate and the development of a constructivist interaction analysis model for computer conferencing. Journal of Educational Computing Research, 17 (4), 395-429.

Gunawardena, Charlotte N., Lowe, Constance A., Anderson, Terry, (1998). Transcript Analysis of Computer-Mediated Conferences as a Tool for Testing Constructivist and Social-Constructivist Learning Theories, 14<sup>th</sup> Annual Conference on Distance Teaching and Learning, (pp. 139-145). Madison: University of Wisconsin System.

Hackman, M. Z. & Walker, K.B. (1990). Instructional communication in the televised classroom: The effects of system design and teacher immediacy on student learning and satisfaction. Communication Education, 39, 196-206.

Harasim, L.M. (1989). On-line education: A new domain. Chapter 4 in R. Mason and A. Kaye (Eds.). Mindweave: Communication, computers, and distance education. New York: Pergammon Press.

Harasim, L.M. (Ed.) (1990a). On-line education: Perspectives on a new environment. New York: Praeger Publishing.

Harasim, L.M. (1990b). Online education: An environment for collaborative and intellectual amplification. In L.M. Harasim (Ed.). On-line education: Perspectives on a new environment. New York: Praeger Publishing.

Harasim, L., Hiltz, S.R., Teles, L., & Turoff, M. (1995). Learning networks. Cambridge, MA: The MIT Press.

Harmin, M. (1994). Inspiring active learning. Alexandria, VA: Association for Supervision and Curriculum Development.

Hartman, K., Neuwirth, C.M., Kiesler, S., Sproull, L., Cochran, C., Palmquist, M., and Zubrow, D. (1995). Patterns of social interaction and learning to write: Some effects of network technologies. In Z. L. Berge and M.P. Collins (Eds.). Computer-mediated communication and online classroom. Vol. 2. Higher Education. Cresskill, NJ: Hampton Press.

Henggi, Yolanda Nokuri, (1998). Changing Roles, Changing Technologies: The Design, Development, Implementation, and Evaluation of a Media Technology and Diversity On-Line Course. Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA. April 13-17. 32p. ERIC NO. ED419517

Henri, F. (1992). Computer-conferencing and content analysis. Chapter 8 in A.R. Kaye (Ed.). Collaborative learning through computer conferencing. New York: Springer-Verlag.

Hiltz, S.R. & Turoff, M. (1978). The network nation: Human communications via computers. Reading, MA: Addison-Wesley.

Hiltz, S.R. (1987). Evaluating the virtual classroom. In Online Education: Perspective on a New Environment, ed. Linda Harasim. New York: Praeger Publishers.

Hiltz, S.R. (1988). A virtual classroom on E.I.E.S. Vol 1: Learning in a Virtual Classroom Research Report 25. Neward, NJ: Center for Computerized Conferencing and Communication.

Hiltz, S.R. (1990). Evaluating the virtual classroom. Chapter 7 in L.M. Harasim (Ed.). On-line education: Perspectives on a new environment. New York, NY: Praeger Publishing.

Hiltz, S.R. and Turoff, M. (1993). The network nation: Human communication via computer. (Revised Ed.). Cambridge, MA: The MIT Press.

Hiltz, S.R. (1994). The virtual classroom. Norwood, NJ: Ablex Press.

Hollingsworth, P., Johnson, D., Smith S. (1998). An evaluation study of interdisciplinary active learning. Roeper Review, May-June v20 n4 p. 273(4).

Hunkins, F.P. (1972). Questioning strategies and techniques. Boston: Allyn and Bacon.

Hunkins, F. P. (1987). "Students as Key Questioners." In Questions, Questioning Techniques, and Effective Teaching, edited by W.W. Wilen, 153-72. Washington DC: National Education Association.

Hunkins, F. P. (1989). Teaching thinking through effective questioning. Boston: Christopher-Gordon.

Janes, J., & Hauer, D. (1988). Now What? Readings on surviving (and even enjoying) your first experience at college teaching. (2<sup>nd</sup> ed.) Acton, MA: Copley.

Jiang, Mingming (1998). Distance Learning in a web-based environment: An analysis of factors influencing students' perceptions of online learning (instructional design). Doctoral dissertation, Albany, State University of New York, School of Education, Department of Theory and Practice. (ProQuest Dissertation AAT 9913679).

Jonassen, D.H. (1991). Objectivism vs. constructivism: Do we need a new philosophical paradigm? Educational Technology: Research & Development, 393, 5-14.

Jonassen, D.H. (1992). Evaluating constructivistic learning. Chapter 12 in T. Duffy and D. Jonassen (Eds.). Constructivism and the technology of instruction: A conversation. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Jones, B.B., Valdez, G., Nowakowski, J., and Rasmussen, C. (1994). Designing learning and technology for educational reform. North Central Regional Educational Laboratory Press (ERIC Document Reproduction No. ED 378 940)

Kanuka, H. and Anderson, T. (1998). Online social interchange, discord, and knowledge construction. Journal of Distance Education, 13 (1) 57-74.

Kaye, A.R. (Ed.) (1992). Collaborative learning through computer conferencing. New York: Springer-Verlag.

Kelmm, W. & Snell, J. (1996). Enriching computer-mediated group learning by coupling constructivism with collaborative learning. E JIST 1 (2) [Online] Available: [www.usq.edu.au/electpub/e-jist/abstrac2.htm](http://www.usq.edu.au/electpub/e-jist/abstrac2.htm)

Kindsvatter, R. (1988). Dynamics of effective teaching. White Plains, NY: Longman Inc.

Klinzing, H. G., and Klinzing-Eurich, G. (1988). "Questions, Responses, and Reactions." In Questioning and Discussion: A Multidisciplinary Study, edited by J. T. Dillon. Norwood, NJ: Ablex.

Kochery, Timothy S., (1997). Distance Education: A Delivery System in Need of Cooperative Learning. In: Proceedings of Selected Research and Development Presentations at the 1997 National Convention of the Association for Educational Communications and Technology (19<sup>th</sup> Albuquerque, NM, February 14-18, 1997) (ERIC Document Reproduction No. ED409847)

Konya, B. A. (1972). "The Effects of Higher- and Lower-Order Teacher Questions on the Frequency and Types of Student Verbalizations." Ph.D. diss., University of Tennessee.

Kurtz, Ruth J. (1994). Using Faculty Peers To Improve Instruction in Diversified College Classrooms, Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 4-8). 20p. (ERIC Document Reproduction No. ED369733)

Lauzon, A.C. and Moore, G.A.B. (1989). A fourth generation distance education system: Integrating computer assisted learning and computer conferencing. The American Journal of Distance Education, 3, 38-49.

Lauzon, A.C. (1992). Integrating computer-based instruction with computer conferencing: An evaluation of a model for designing online education. The American Journal of Distance Education, 6, 32-46.

Lazear, D. (1991). Seven ways of teaching. Palatine, IL: Skylight Publishing.

Lehman, J.D., McInerney, W.D., and White, G.A. (1993). Seventy cups of coffee, office politics and computer or how a computer mediated distance education course was created. Proceedings of the Madison, WI Distance Education Conference: Teaming Up for Success. Madison: University of Wisconsin.

Levin, J., Kim, H., and Riel, M. (1990). Analyzing instructional interactions on electronic message networks. In L.M. Harasim (Ed.), On-Line education: Perspectives on a new environment (pp. 185-213). New York: Praeger.

Levin, T., with Long, R. (1981). Effective instruction. Washington DC: Association for Supervision and Curriculum Development.

Luallen, J. and Leonard, D. (1991). Using what we are learning about learning: Talking less and listening more: A means of helping students make sense of science. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (Lake Geneva, WI, April 7-10, 1991). 22p.(ERIC Document Reproduction No: ED342622)

McDonald, Jeannette (1998). Interpersonal aspects of group dynamics and group development in computer conferencing. The American Journal of Distance Education, June.

McDonald, Jeannette (1999). Personal communication, November 7, 1999.

Macabe, M.F. (1997). Online classrooms: Case studies of computer conferencing in higher education (distance education). Unpublished doctoral dissertation, Columbia University Teachers College. AAC 9734078. (ProQuest-Dissertation Abstracts).

Marzano, R. (1992). A different kind of classroom: Teaching the dimensions of learning. Alexandria, VA: Association for Supervision and Curriculum Development.

Mason, R. (1992). Moderating educational computer conferencing. Electronic Networking: Research, Applications, and Policy, 3.

Mason, R. (1993). Computer conferencing: The last word. Victoria, BD: Beach Holme Publishers.

Mason, R. (1997). Moderating educational computer conferencing. [Online]. Available: <http://star.ucc.nau.edu/~mauri/papers/mason.html>

Mason, R. and Kaye, A. (Eds.) (1989). Mindweave: Communication, computers and distance education. New York: Pergamon.

Merriam, S. and Caffarella, R. (1999). Learning in Adulthood, 2<sup>nd</sup> ed. San Francisco: Jossey-Bass.

Mills, S.; Rice, C.; Berliner, D.; and Rousseau, E. (1980). Correspondence between teacher questions and student answers in classroom discourse. Journal of Experimental Education 48: 194-204.

Moore, M.G. (1993). Theory of transactional distance. In D. Keegan (Ed.), Theoretical principles of distance education. New York: Routledge.

Moreno, J.L. (1960). The sociometry reader. Illinois: The Free Press.

Muscella, D. and DiMaura, V. (1995). Talking about science: the case of an electronic conversation. TERC, Cambridge, MA (ERIC Document Reproduction No. ED 395 765)

National Teachers Enhancement Network. (1998). Taking the Distance Out of Distance Learning, Lessons Learned. A faculty development workshop on best practices in distributed learning, Montana State University, Bozeman, MT.

Nelson, G. (1999). Earth Systems Science Course Syllabus, [Electronic Data File]. National Teachers Enhancement Network, Montana State University-Bozeman.

Newman, D.R., Webb, B. and Cochrane, C. (1995). A content analysis method to measure critical thinking in face-to-face and computer supported group learning. Interpersonal computing and technology: an Electronic Journal for the 21<sup>st</sup> Century. ISSN: 1064-4326, April 1995. Volume 3, number 2, pp. 56-77.

Northway, M.L. (1952). A primer of sociometry. Toronto: University of Toronto Press.

Office of Educational Research and Improvement, (1994). Questioning and understanding to improve learning and thinking (QUILT): The evaluation results. A Proposal to the National Diffusion Network (NDN), Documenting the Effectiveness of the QUILT Professional, Feb, 29 p. Appalachia Educational Laboratory, Charleston WV (ERIC Document Reproduction No. ED 403230)

Palincsar, A.S. and Brown, A.L. (1988). Teaching and practicing thinking skills to promote comprehension in the context of group problem solving. Remedial and Special Education, 9 (1), 35-39.

Palloff, R.M. and Pratt, K. (1999). Building learning communities in cyberspace: Effective strategies for the online classroom. San Francisco: Jossey-Bass.

Pappert, S. (1993). The children's machine: Rethinking school in the age of the computer. New York: Basic Books.

Perkins, D.N. (1992). Technology meets constructivism: Do they make a marriage? Chapter 4 in T. Duffy and D. Jonassen (Eds.). Constructivism and the technology of instruction: A conversation. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Phillips, B. (1971). Social research strategy and tactics. New York: Macmillan Company.

Pratton, J. and Hale, L. (1986). The effects of active participation on student learning. Journal of Educational Research, 79 (4), 210-215.

Presseisen, B.Z. (1992). A perspective on the evolution of cooperative thinking. In N. Davidson and T. Worsham (Eds.). Enhancing thinking through collaborative learning. New York, Teachers College, Columbia University.

Renzulli, J.S., and Reis, S.M. (1985). The schoolwide enrichment model. Mansfield Center, CT: Creative Learning Press.

Ritchie, H. and Newby, T.J. (1989). Classroom lecture/discussion versus live televised instruction: A comparison of effect on student performance, attitude and interaction. The American Journal of Distance Education, 3, 36-45.

Robson, C. (1993). Real world research. Oxford: Blackwell.

Ross, W. (1860). Methods of instruction. Barnard's American Journal of Education 9: 367-79.

Rowe, M. B. (1974). Relation of wait time and rewards to the development of language, logic, and fate control: Part one-wait time." Journal of Research in Science Teaching, 11: 81-94.

Rowe, M. B. (1986). Wait time: Slowing down may be a way of speeding up! Journal of Teacher Education, 37: 43-50.

Rowe, M. B. (1987). Using wait time to stimulate inquiry. In Questions, Questioning Techniques, and Effective Teaching, edited by W.W. Wilen, 95-106, Washington DC: National Education Association.

Russell, T. (1999). The no significant difference phenomenon. Office of Instructional Telecommunications, North Carolina State University. Raleigh, NC. Available: <http://cuda.teleeducation.nbc.ca/nosignificantdifferece/>

Sanders, N.M. (1966). Classroom questions: What kinds. New York: Harper & Row.

Selltiz, C., Wrightsman, L. and Cook, S. (1976). Research methods in social relations. New York: Holt, Rinehart and Winston.

Semple, E. Jr. (1982). A review of the literature of sociometry. Information Analyses (070) (ERIC Reproduction Document No. ED 224 838)

Shearer, Rick L., Rose, Bill, (1998). CMC environments designed to facilitate multiple levels of interaction, 14<sup>th</sup> Annual Conference on Distance Teaching and Learning, (pp. 353-357). Madison: University of Wisconsin System.

Simon, C. (1992). Telematic support for in-service teacher training. Chapter 2 in A.R. Kaye (Ed.). Collaborative learning through computer conferencing. New York: Springer-Verlag.

Slavin, R.E. (1990). Cooperative learning: Theory, research, and practice. Englewood Cliffs, NJ: Prentice Hall.

Smith, P.S. (1997). Evaluation of the national teacher enhancement network: Final Report. May, Horizon Research, Inc.

Smith, P.S. (1999a). Evaluation of the national teachers enhancement network: Final Report. November, Horizon Research, Inc.

Smith, P. S. (1999b) Personal communication, December 10, 1999.

Smith, P.S. and Taylor, E.S. (1999) Personal communication, April 10, 1999.

Stamps, D. (1999). My anonymous adventures in cyberspace. Training, April, v36 i4 p50(8).

Stevens, R. (1912). The question as a means of efficiency in instruction: A critical study of classroom practice. New York: Teachers College, Columbia University.

Stein, M. (1999). Teaching Adolescent Nutrition Course Syllabus, [Electronic Data File] National Teachers Enhancement Network, Montana State University.

Taba, H.; Levine, S.; and Elzey, F. (1964). Thinking in elementary school children, U.S. Office of Education, Dept. of Health, Education and Welfare, Cooperative Research Project No. 1574. San Francisco: San Francisco State College.

Tagg, A.C. (1994). Leadership from within: Student moderation of computer conferences. The American Journal of Distance Education. 8 (3), 40-50.

Thornber, N.S. (1999). Quantum Mechanics Course Syllabus, [ Electronic Data file]. National Teachers Enhancement Network, Montana State University-Bozeman.

University of Victoria (1996). Learn Skills Program – Bloom’s Taxonomy, Counseling Services, Available:  
<http://www.coun.uvic.ca/learn/program/hndouts/bloom.html>

USAID Policy Roundtable Series. (1999). Higher education uses of internet technologies: New applications for international development. Policy Roundtable #7. June 15. Washington, D.C.

U.S. Congress, Office of Technology Assessment. (1989). Linking for learning: A new course for education. (Report no. OTA-SET-430). Washington, DC: U.S. Government Printing Office.

Vygotsky, L.S. (1962). Thought and language. Cambridge, MA.: MIT Press.

Vygotsky, L.S. (1986). Thought and language. Cambridge, MA: the MIT Press.

Vygotsky, L.S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

Wagner, Ellen D., (1998). Interaction strategies for online training designs, 14<sup>th</sup> Annual Conference on Distance Teaching and Learning, (pp. 417-421). Madison: University of Wisconsin System.

Wasserman, S., & Faust, K. (1997). Social network analysis methods and applications. United Kingdom: Cambridge University Press.

Webb, N. (1991). Task-related verbal interaction and mathematics learning in small groups. Journal for Research in Mathematics Education 22(5): 366-89.

Wells, R. (1993). Computer-mediated communication in distance education: An international review of design, teaching and institutional issues. Research Monograph No. 6. University Park, PA: The American Center for the Study of Distance Education.

WestEd 1999). Bloom's taxonomy in distance learning resource guide, Available: <http://www.wested.org/tie/dlrn/blooms.html>

Western Cooperative for Educational Telecommunications (1994). New Pathways to a Degree: Using Technologies to Open the College, Annenberg/CPB.

White, J. (1990). Involving different social and cultural groups in discussion." In Teaching and Learning Through Discussion, edited by W.W. Wilen. Springfield, IL: Charles C. Thomas Publisher.

Wilen, W. (1985). Questioning, thinking and effective citizenship. Social Science Record, Spring 22: 4-6.

Wilen, W. (Ed.) (1987). Questions, questioning techniques, and effective teaching. NEA Mastery in Learning Project, NEA Professional Library, National Education Association, Washington, DC.

Wilen, W. (1988). Review of pedagogical perspectives. In Questions and Questioning: A Multidisciplinary Study, edited by J. T. Dillon, Norwood, NJ: Ablex.

Wilen, W.W. ed. (1990). Teaching and learning through discussion. Springfield, IL: Charles C. Thomas Publisher.

Wilen, W. (1991). Questioning skills for teachers. What research says to the teacher. Third Edition, NEA Professional Library, West Haven, CT, National Education Assoc. Washington DC pp. 43 (ERIC Document Reproduction No. ED332983)

Wilen, W. and White, J. (1989). Interaction and discourse in social studies Classrooms. In Handbook of Research on Social Studies Teaching and Learning, edited by J. Shaver. New York: Macmillan.

Williams, F., Rice, R., and Rogers, E., (1988). Research methods and the new media. New York: The Free Press.

Winn, W. (1992). The assumptions of constructivism and instructional design. Chapter 17 in T. Duffy and D. Jonassen (Eds.). Constructivism and the technology of instruction: A conversation. Hillsdale, New Jersey: Lawrence Erlbaum Assoc.

Wood, D. and Wood, H. (1988). Questioning vs. student initiative. In Questioning and Discussion: A Multidisciplinary Study, edited by J. T. Dillon, 280-305. Norwood, NJ: Ablex.

Wragg, E.C. (1984). Classroom teaching skills. New York: Nichols Publishing Co.

APPENDICES

APPENDIX A

NTEN COURSES	FirstClass	Graduate	12+ Stu	Required	Biology or	Selected
	In-Tact			Interaction	Phys. Sci.	
<b>BIOLOGY</b>						
Biology of Riparian Zones and Wetlands	X	X	X	X	X	X
Life in Streams and Ponds of the Northern Great Plains		X	X	X	X	
Terrestrial Ecology of Plains and Prairies *	X	X	X	X	X	X
<b>CHEMISTRY</b>						
Chemistry Concepts		X	X	X	X	
Modern Organic and Biochemistry		X	X	X	X	
<b>EARTH SCIENCES</b>						
Electronic Hydrology	X	X	X	X	X	X
Electronic Snow		X	X	X	X	
Hydrology of Streams & Ponds of the Northern Great Plains		X	X	X	X	
Mineral Resources, Economics, & the Environment	X	X	X	X	X	X
Mountains and Plains Riparian Process	X	X	X	X	X	X
Mountain Streams & Lakes		X		X	X	
Plains Landscapes	X	X	X	X	X	X
<b>EDUCATION</b>						
Landforms/Lifeforms: Interdisciplinary Studies in Science Ed	X	X	X	X		
Environmental Science Education: Ecological Field Studies	X	X	X	X		
<b>ENGINEERING</b>						
Designing Technology-Based Solutions		X	X	X		
<b>Entomology</b>						
School Intergrated Pest Management		X	X	X		
<b>HEALTH &amp; HUMAN DEVELOPMENT</b>						
Dining on DNA: An Exploration of Food Biotechnology		X	X	X	X	
Nutrition for Fitness & Performance	X	X	X	X	X	X

TOTAL POOL OF NTEN COURSES AND COURSES SELECTED  
FOR THIS STUDY

APPENDIX A

Teaching Adolescent Nutrition	X	X	X	X	X	X
<b>LAND RESOURCES &amp; ENVIORNMENTAL SCIENCES</b>						
Dirty Dozen: 12 Principles of Soil Science	X	X	X	X	X	X
Water Quality		X	X	X	X	
<b>MATHEMATICAL SCIENCES</b>						
Advanced Mathematical Modeling		X	X	X		
Integrating Mathematics & Science through Modeling			X	X		
Visualization and Communication Tools for Teachers	X	X		X		
Earth Systems Science	X	X	X	X	X	X
<b>MICROBIOLOGY</b>						
Infection & Immunity	X	X	X	X	X	X
<b>PHYSICS</b>						
Advanced Physics by Inquiry		X	X	X	X	
Astronomy for Teachers		X	X	X	X	
Comparative Planetology		X	X	X	X	
Conceptual Physics	X		X	X	X	
Demystifying Quantum Mechanics	X	X	X	X	X	X
General Relativity	X	X	X	X	X	X
Modern Physics for Teachers		X		X	X	
Particle Physics for Teachers	X	X	X	X	X	X
Physics of Energy		X	X	X	X	
Science & Photography	X	X	X	X	X	X
Special Relativity	X			X	X	
Studying the Universe with Space		X	X	X	X	
<b>PLANT, SOIL &amp; ENVIRONMENTAL SCIENCES</b>						
Agricultural & Medical Biotechnology	X	X	X	X	X	X
* Eliminated following review						

APPENDIX B

Search 16 Files 0 Folders MontanaPBS : kobbink

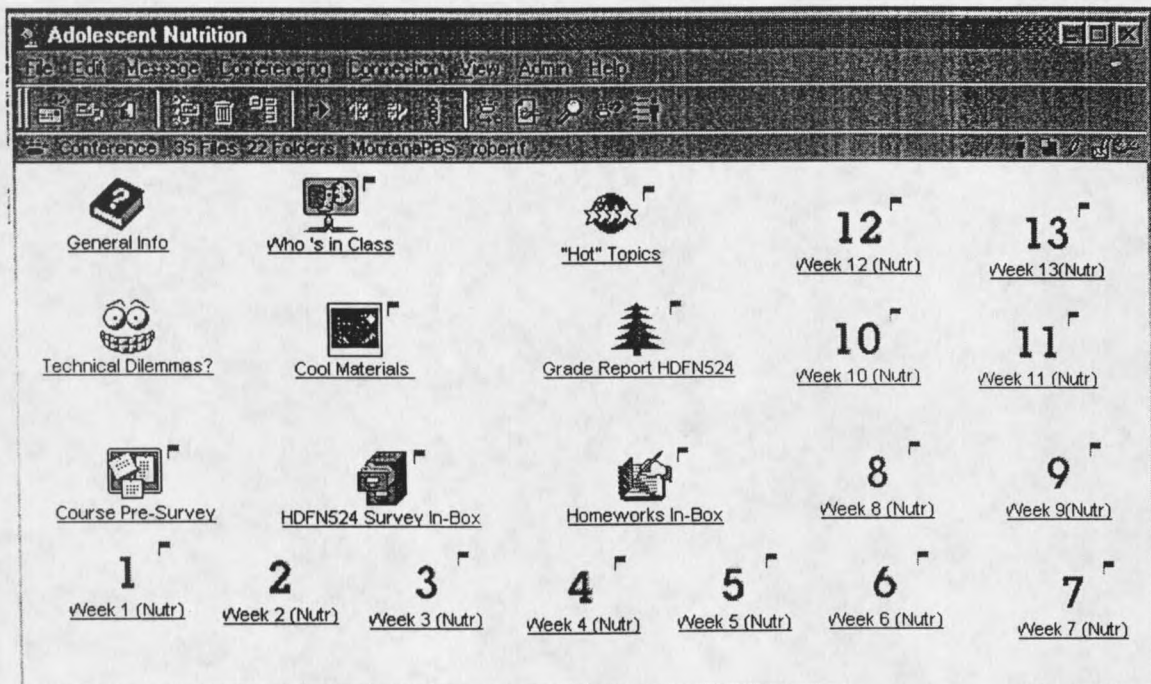
<input checked="" type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Name	Siz	<input type="checkbox"/> Subject	Last Mo
<input checked="" type="checkbox"/>		<u>Joan Cory</u>	<u>2</u>	<input type="checkbox"/> <u>One sentence definitions</u>	<u>6/15/99</u>
<input checked="" type="checkbox"/>		Candy Surdez	2	Re: One sentence definitions	6/15/99
<input checked="" type="checkbox"/>		Bradley Charles	2	Re: One sentence definitions	6/16/99
<input checked="" type="checkbox"/>		Nancy Jurecka	2	Re: One sentence definitions	6/16/99
<input checked="" type="checkbox"/>		Ann Lukey	2	Re: One sentence definitions	6/16/99
<input checked="" type="checkbox"/>		Louise Jasko	2	Re: One sentence definitions	6/17/99
<input checked="" type="checkbox"/>		Louise Jasko	2	Re: One sentence definitions	6/17/99
<input checked="" type="checkbox"/>		Louise Jasko	1	Re(2): One sentence definitions	6/17/99
<input checked="" type="checkbox"/>		Nancy Jurecka	2	Re(3): One sentence definitions	6/17/99
<input checked="" type="checkbox"/>		Joan Cory	2	Re(2): One sentence definitions	6/18/99
<input checked="" type="checkbox"/>		Joan Cory	2	Re(3): One sentence definitions	6/18/99
<input checked="" type="checkbox"/>		Edward Marshall	1	Re: One sentence definitions	6/19/99
<input checked="" type="checkbox"/>		SchiChin Wei	3	Re: One sentence definitions	6/20/99
<input checked="" type="checkbox"/>		Susan Terry	2	One sentence definitions	6/16/99
<input checked="" type="checkbox"/>		Linda S. Hanson	2	One sentence definitions	6/16/99
<input checked="" type="checkbox"/>		Suzanne Simoneau	2	More one sentence definitions	6/20/99

SAMPLE DISCUSSION THREAD

APPENDIX B

APPENDIX C

## APPENDIX C

SAMPLE OF ELECTRONIC CLASSROOM ORGANIZATION  
USING FIRSTCLASS™

APPENDIX D

APPENDIX D

## SAMPLE QUESTIONS AND COGNITIVE LEVELS

Question #	Question	Cues	Level I	Level II	Level III	Level IV
107	Compare and contrast factors or processes which control the patchworks in meandering & braided hydrosystem sections	Compare, contrast			X	-
100	Compose the homework assignment for your classmates for week 11	Compose				X
38	Name other books on the subject you have enjoyed?	Name	X			
65	What are some of the benefits and the concerns regarding the use of human gene therapy?	What		X		
176	Compare energy production in the movements between you and a classmate and discuss your rationale for the difference	Compare, discuss			X	
59	What are some of the main points that Feynman has made so far?	What		X		

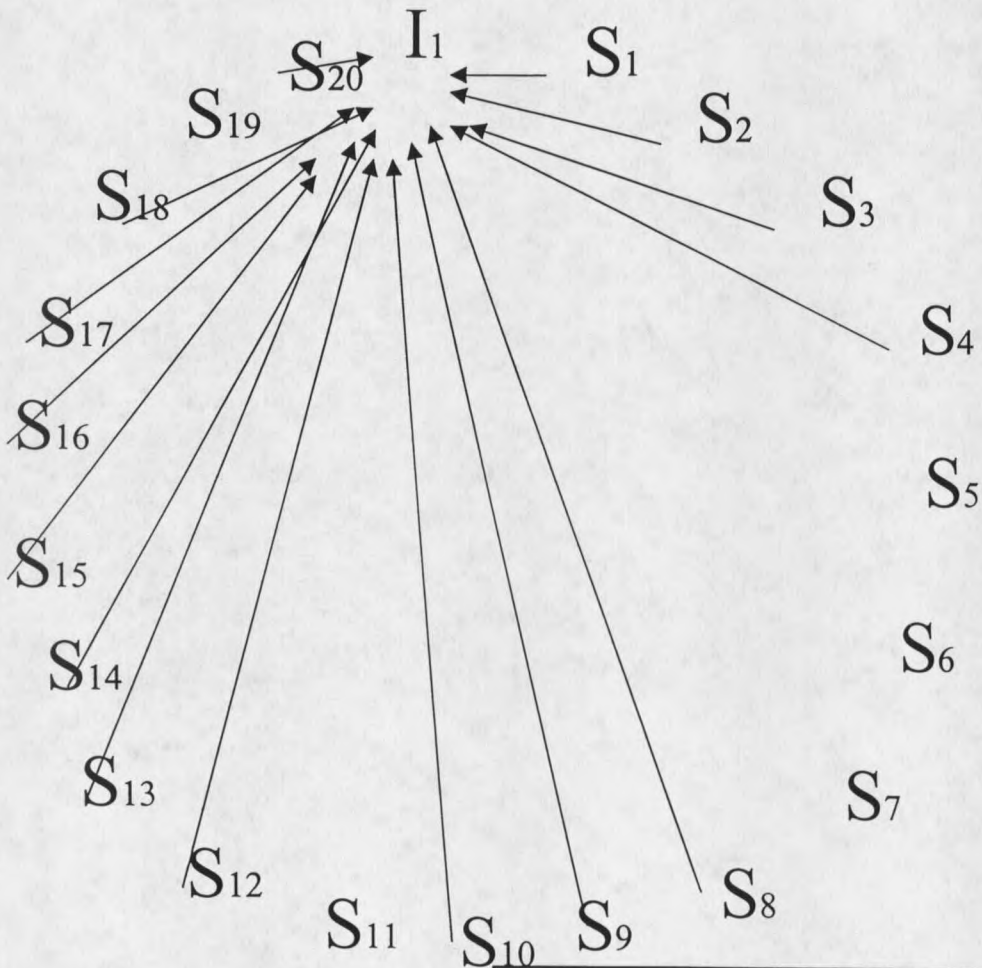
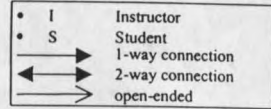
APPENDIX E



APPENDIX E-CONTINUED

DISCUSSION DIAGRAM SAMPLES

#100



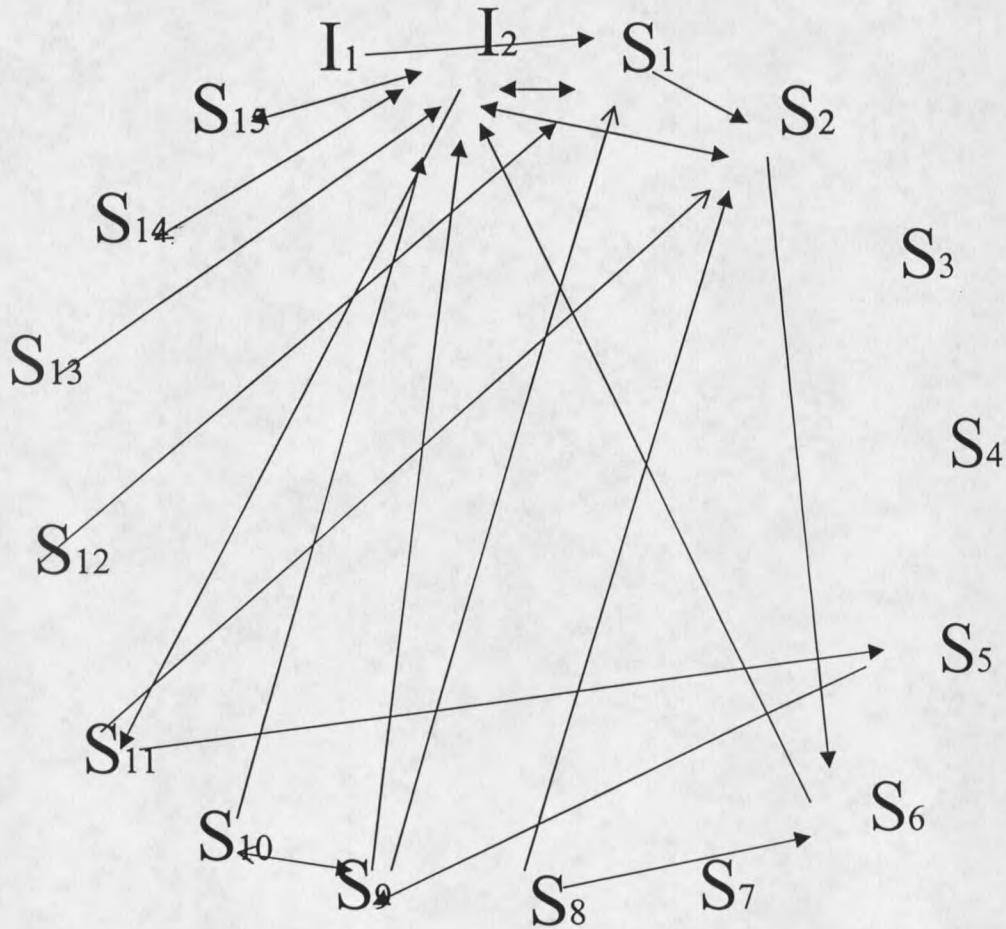
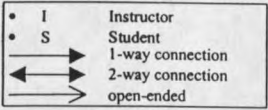
Earth Science - Level IV  
 Compose the homework assignment for week 11.

Index #100	Formula	Value
Student Participation	$(15/20) \cdot 100$	75%
Total Interaction Potential	$(15/210) \cdot 100$	7%
Instructor-mediated Interaction Potential	$(15/20) \cdot 100$	75%
Instructor-independent Interaction Potential	$(0/190) \cdot 100$	0%

APPENDIX E-CONTINUED

DISCUSSION DIAGRAM SAMPLES

#59



Physics-Level II

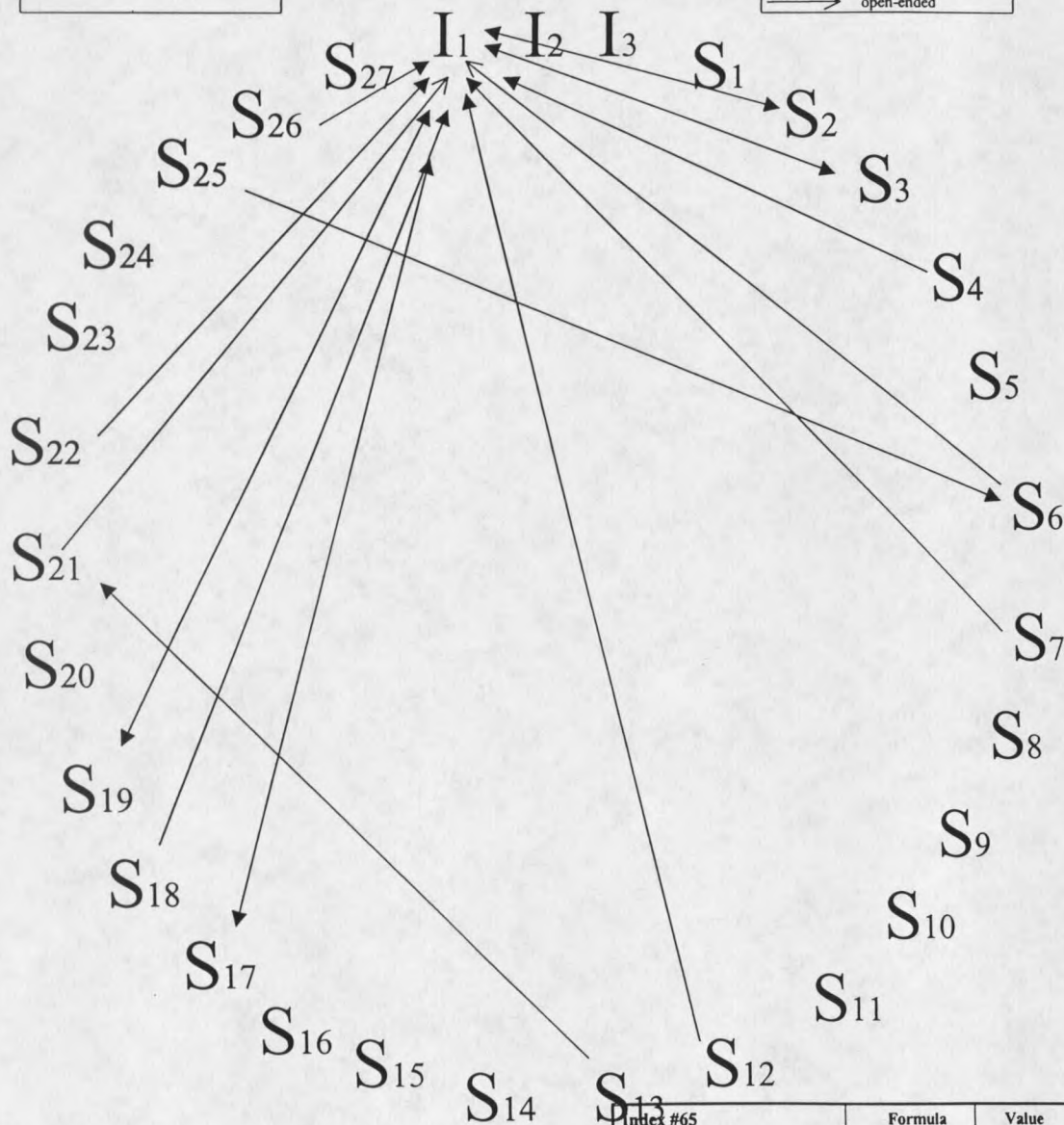
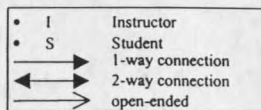
What are the main points Feynman has made so far?

Index #59	Formula	Value
Student Participation	$(12/15) \cdot 100$	80%
Total Interaction Potential	$(20/136) \cdot 100$	15%
Instructor-mediated Interaction Potential	$(10/30) \cdot 100$	33%
Instructor-independent Interaction Potential	$(10/105) \cdot 100$	10%

APPENDIX E-CONTINUED

DISCUSSION DIAGRAM SAMPLES

#65



Biology-Level II

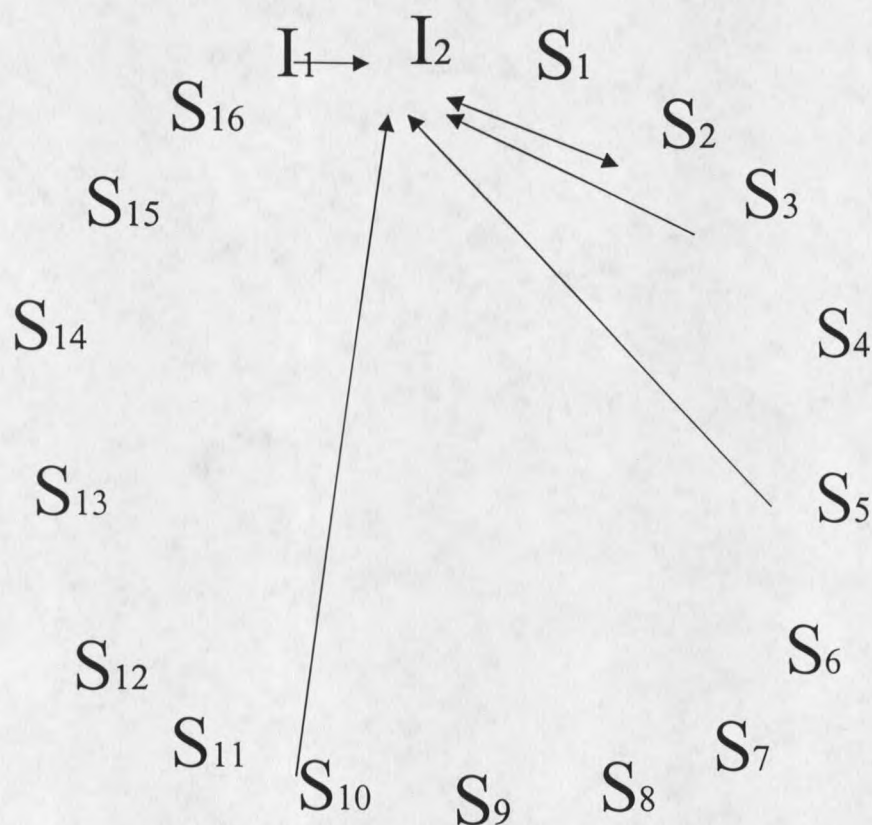
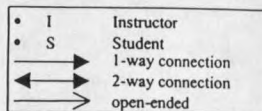
What are some of the benefits and concerns regarding the use of human gene therapy?

Index #65	Formula	Value
Student Participation	$(14/27) \cdot 100$	52%
Total Interaction Potential	$14/435 \cdot 100$	3%
Instructor-mediated Interaction Potential	$(12/81) \cdot 100$	15%
Instructor-independent Interaction Potential	$(2/351) \cdot 100$	1%

## APPENDIX E-CONTINUED

## DISCUSSION DIAGRAM SAMPLES

#38



Physics - Level I

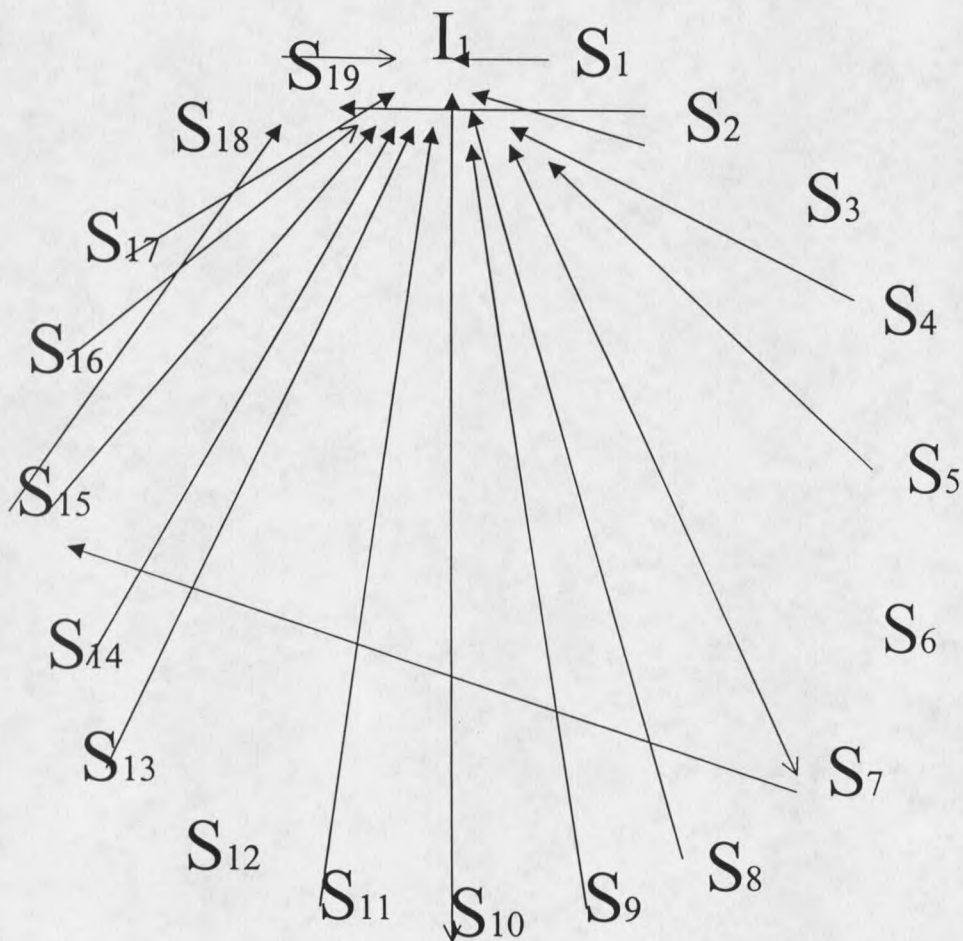
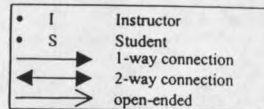
Name other books on the subject  
that you have enjoyed.

Index #38	Formula	Value
Student Participation	$(4/16)*100$	25%
Total Interaction Potential	$(5/153)*100$	3%
Instructor-mediated Interaction Potential	$(4/32)*100$	13%
Instructor-independent Interaction Potential	$(0/120)*100$	0%

## APPENDIX E-CONTINUED

## DISCUSSION DIAGRAM SAMPLES

#176



Biology - Level III

Compare energy production in the movements between you and a classmate and discuss your rationale for the difference.

Index #176	Formula	Value
Student Participation	$(15/19)*100$	79%
Total Interaction Potential	$(18/190)*100$	9%
Instructor-mediated Interaction Potential	$(15/19)*100$	79%
Instructor-independent Interaction Potential	$(3/171)*100$	2%

APPENDIX F

APPENDIX F

## THE MEANS OF THE FOUR INTERACTION INDICIES BY COURSE

Course		Student Participation	Total Interaction Potential	Instructor- Mediated Potential	Instructor- Independent Potential
Biology of Riparian Zones	Mean	.4912	.0702	.0435	.0331
	N	3	3	3	3
	Std. Deviation	.2293	.0506	.2191	.0389
Electronic Hydrology	Mean	.5076	.0459	.4432	.0114
	N	22	22	22	22
	Std. Deviation	.2263	.0206	.2131	.0108
Mineral Resources, Economics & The Environment	Mean	.8714	.1403	.4405	.0786
	N	10	10	10	10
	Std. Deviation	.0451	.0251	.0466	.0335
Mountains & Plains Riparian Processes	Mean	.5227	.0972	.4773	.0212
	N	12	12	12	12
	Std. Deviation	.1650	.0278	.1981	.0267
Plains Landscapes	Mean	.7200	.0967	.7200	.0762
	N	5	5	5	5
	Std. Deviation	.1193	.0162	.1193	.0104
Nutrition For Fitness	Mean	.7870	.1248	.7491	.0555
	N	43	43	43	43
	Std. Deviation	.0974	.0419	.1595	.0399
Teaching Adolescent Nutrition	Mean	.9058	.2803	.3379	.2733
	N	23	23	23	23
	Std. Deviation	.1891	.1347	.1338	.1849
Soil Science	Mean	.6583	.0643	.6250	.0526
	N	6	6	6	6
	Std. Deviation	.2905	.0244	.3078	.0666
Earth Systems Science	Mean	.9101	.3851	.9024	.2430
	N	4	4	4	4
	Std. Deviation	.0782	.1956	.2677	.1357
Infection & Immunity	Mean	.3889	.0509	.1975	.0167
	N	9	9	9	9
	Std. Deviation	.2437	.0412	.1238	.0238

APPENDIX F-CONTINUED

Quantum Mechanics	Mean	.4381	.0714	.1905	.0381
	N	7	7	7	7
	Std. Deviation	.2138	.0437	.0810	.035
General Relativity	Mean	.3750	.0490	.1788	.0116
	N	18	18	18	18
	Std. Deviation	.1953	.0283	.0999	.0188
Particle Physics	Mean	.3462	.0365	.1365	.0200
	N	10	10	10	10
	Std. Deviation	.2551	.0306	.0957	.0214
Science & Photography	Mean	.2211	.0219	.1000	.0468
	N	5	5	5	5
	Std. Deviation	.2720	.0287	.1268	.0763
Ag & Medical Biotechnology	Mean	.3368	.0252	.1053	.0677
	N	32	32	32	32
	Std. Deviation	.1985	.0192	.0632	.0105
Total	Mean	.5845	.1011	.4000	.0582
	N	209	209	209	209
	Std. Deviation	.2854	.1027	.2865	.1073

MONTANA STATE UNIVERSITY - BOZEMAN



3 1762 10335648 9