VISUALIZING UNDERSTANDINGS ONLINE:
NONTRADITIONAL PHARMACY STUDENTS’ EXPERIENCES
WITH CONCEPT MAPPING

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the
Graduate School of The Ohio State University

By
Cable Thomas Green, M.P.C.

The Ohio State University
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Dissertation Committee:
Professor Thomas McCain, Adviser
Professor Anita Woolfolk Hoy
Professor Phillip Smith
Professor Stephen Acker

Approved by

____________________
Adviser
Communication Graduate Program
ABSTRACT

Learning with technology is a challenge for both designers of and students in online degree programs. Due to new accreditation standards, pharmacists are returning to school. Pharmacy professionals, looking to update their skills, understandings and degree, find themselves overwhelmed with new information and are often without the capacity to incorporate it effectively into their practice. The implications for postsecondary education are profound. Information overload is the operative mode in which students and teachers now exist. Learning in this information rich environment requires different tools and pedagogical methods than are currently used in online learning environments. This dissertation is a report of how pharmacists can learn and communicate in new ways to become better practitioners and better learners.

The practical work of developing and testing usable knowledge about online learning environments requires a fundamental understanding of the learning and technology experiences students bring with them to their learning environment, conceptual change processes, information visualization tools to help students visualize what they know, and collaborative learning pedagogies to facilitate sharing of students’ understandings.
This study explores the role of concept mapping as a tool to help students visualize what they know and to communicate their understandings with other students in an online learning community. While the pharmacists did concept map their understandings and acknowledged the benefits of working together, they did not share their concept maps. This study proposes a collaborative online learning community model for nontraditional students to explain these results. The model suggests the following. First, becoming an expert with a new tool takes time, hands on experience and may be a prerequisite to using the tool to learn and communicate in a learning community. Second, for students to move past public presentation of their ideas and into collaborative peer review of others’ understandings, teachers must understand the decision making risk analysis nontraditional students employ. Third, building functional learning communities is difficult and takes time.

Further research is needed to determine if these changes in how concept mapping is implemented and prioritized affect nontraditional students’ sharing of understandings in online learning environments. GIF, QuickTime and WAV files are included.
Dedicated to my lovely Lesley.
ACKNOWLEDGMENTS

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I thank Dr. Stephen Acker for always including me in educational technology developments at The Ohio State University, for his critical eye and his wild metaphors. My thanks to Dr. Anita Woolfolk Hoy for opening my eyes to learning theory and concept mapping. Anita also reminds me to never settle for less than my dreams. I am grateful to Dr. Phillip Smith for teaching me how the mind works in conjunction with good design. I also wish to thank Dr. Alan Escovitz for his career advice and for my position in the College of Pharmacy and Dr. Dennis Mungall for allowing my to run my research in our online doctoral program. Without these professors’ generous efforts, this dissertation would not have been possible.
VITA

October 8th, 1972.......................... Born – Seoul, South Korea
1995............................................. B.S., Lewis and Clark College
1997............................................. M.P.C. Communication, Westminster College
1997 – 2000................................. Graduate Teaching Associate
               The Ohio State University
1997 – 2000................................. Director of Instructional Technology
               Council of Ohio Colleges of Pharmacy
2000 – Present............................. Director of Educational Technology
               Assistant Professor
               College of Pharmacy, The Ohio State University

FIELDS OF STUDY

Major Field: Communication

               Educational Technology
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PREFACE

The Ohio State University required this dissertation be submitted in electronic format. This document is available in Adobe Acrobat® (.PDF) format and can be downloaded from http://www.ohiolink.edu/etd. The reader may read this document on the computer screen or in print. To access the multimedia objects embedded in this dissertation, however, this document must be accessed in Adobe Acrobat® format.

The reader will need the following software to access the multimedia objects in this dissertation: Adobe Acrobat Reader® to view the .PDF version of this dissertation, Apple QuickTime® to view the videos, a graphics program to view the concept maps, and an audio program to hear the audio files. Click on these outlined links to test your ability to view / hear these multimedia objects.
CHAPTER 1: STATEMENT OF THE PROBLEM

INTRODUCTION

Learning with technology is a challenge for both designers of and students in online degree programs. Due to new accreditation requirements, pharmacists are returning to school. Pharmacy students, looking to update their skills, understandings and degree, find themselves overwhelmed with new information and are often without the capacity to incorporate it effectively into their work. The implications for nontraditional postsecondary education are profound. Information overload is the operative mode in which students and teachers now exist. Learning in this information rich environment requires different tools and pedagogical methods than are currently used in online learning environments. This dissertation is a report of how pharmacists can learn in new ways to become better pharmacists and better learners.

The practical work of developing and testing usable knowledge about online learning environments requires a fundamental understanding of: (1) the learning and technology experiences students bring with them to the learning environment, (2) the basic cognitive processes underlying conceptual change, (3) information
visualization tools to help students visualize their existing conceptual understandings and monitor how their understandings change over time, and (4) collaborative learning pedagogies to facilitate sharing of students’ understandings. Understanding these processes might assist in the design of collaborative online learning communities. This new space might allow professional workers to use their visualized understandings not only to manage their own conceptual change processes, but also to collaborate with other students so all students may benefit from the existing distributed expertise and diverse understandings inherent in their online learning community. Figure 1 is a concept map of the problem statement and how these fundamental ideas are linked in this dissertation.
Figure 1: Concept map of the problem statement and how this dissertation approaches the problem.
Problem Statement

Working professionals are required to make conceptual changes on a near continual basis, and yet their family and work schedules often do not permit them to learn in traditional spaces and times. As much as 50 percent of all employees’ skills become outdated in three to five years (Blodgett, 2000). In the industrial age almost everything a student needed to know in a particular job could be learned at work. This is no longer feasible due to the ubiquity of information and the necessary skills and tools to make meaning from it. Higher levels of education are also required in today’s workplace. Eighty five percent of current jobs require education beyond high school, up from 65 percent in 1991 (U.S. Web-Based Education Commission, 2000). As jobs transform themselves and develop in unprecedented directions, professional workers need to continually update their skills and understandings. New tools, pedagogies, and learning spaces are needed to help professional mid-career students continually update their understandings.

Purpose of the Study

This study explores the role of concept mapping as a tool for nontraditional PharmD students to visualize, manage and share their understandings in an online learning environment. The purpose of this study is to gain a deeper understanding of how to design a learning space within which a community of online students can collectively share their existing expertise and work together to understand new information.
The knowledge gained from this effort provides a basis for recommendations for the Nontraditional PharmD program on how to restructure its online learning environment to foster a learning context within which students can better share their understandings. The study also proposes a collaborative online learning community model for nontraditional students that might be used to review other online learning environments.

Professional Significance of the Study

The increasing number of nontraditional students entering online learning environments is not likely to diminish. As the demands of the workplace continually pressure professionals to update their understandings, it is important for educators to understand how to design effective nontraditional online learning environments.

The use of concept mapping as a tool to visualize, manage and change one’s conceptual framework has been widely tested. The tool has not, however, been used with nontraditional students as a method to enable sharing of understandings in an online learning environment.

This study identified under what conditions practicing pharmacists accept and integrate new tools and pedagogies into their learning environment. The findings also provide a framework for pre-categorizing nontraditional students to better understand what technology and learning experiences they bring to their learning environment. Finally, the study proposes a collaborative online learning community model for nontraditional students, which might be useful to teachers who design and operate online learning environments.
Background of the Study

This section presents the major societal and professional developments that influenced this study. The section begins with an introduction to nontraditional students including their rise in number and a description of their profile. Next, developments in the pharmacy profession, the subsequent effect on working pharmacists, and the resulting online Nontraditional PharmD program are discussed.

The Rise of Nontraditional Students

To meet the informational demands of their jobs, many professionals are returning to school to update their skills and knowledge base. These students, however, no longer have the time, the patience, or the life schedule to conform to the University’s schedule at conventional campuses during conventional times with conventional forms of learning (Brown & Duguid, 1995). With the introduction of online degree programs, more adults are going back to school. Levine (2000) suggested nontraditional students is the fastest growing segment in postsecondary education. While institutions of higher education regularly refer to online students as “nontraditional,” referring to them as such may be a misnomer1 due to their sheer increase in numbers. While seventy million adults are estimated to be taking postsecondary courses, just 16 percent of postsecondary students fit the traditional 18 to 22 year-old profile, attend school full-time and lived on campus (National Center for Education Statistics, 2000).

1 Similarly, these students may be labeled “new traditional” in the near future. As online learning becomes a standard learning environment option for students of all ages and grades, a new class of traditional students will likely encounter many of the same learning issues that today’s nontraditional students face.
In its second survey of distance education programs, the US Department of Education found the number of online students increased by 72 percent from 1995 to 1998. Moreover, an additional 20 percent of the institutions surveyed plan to establish online degree programs by 2003 (Polichar & Bagwell, 2000). Schön (1973) argued, three decades ago, that universities should begin thinking of education beyond the stable state. At the same time, Toffler (1970) predicted the students would compel universities to prepare for life-long learners and even consider learning contracts instead of the conventional on-campus degree programs (Brown & Duguid, 1995). These predictions have emerged as realities and online learning has become widely implemented across postsecondary educational institutions.

Profile of Nontraditional Students

Who are these 21st century nontraditional students? Nontraditional students are voluntarily seeking further education, and are therefore more intrinsically motivated and self-regulated than are traditional students. They have postsecondary education goals with expectations for higher grades (Schlosser & Anderson, 1994) and are willing to initiate dialogue with teachers and other students for assistance. They are often employed in a field where career advances can be readily "achieved through academic upgrading in an online learning environment" (Ross & Powell, 1990, pps. 10-11) and have previous completion of a college degree. For the most part these mid-career students are professionals with several years of work.

---

2 More than 1,100 colleges and universities in the United States, as well as hundreds of institutions in other countries, offered courses on the web (Newmann & Scurry, 2001).
experience and are returning to postsecondary education for a number of reasons, both professional and personal. Some of these reasons include: (1) downsizing: with the loss of company loyalty and job security, workers are reexamining the need to enhance their own marketability; (2) changing world economy: success in the workplace requires competencies for strategically managing and communicating complex information; and (3) changing lifestyles: with advances in technology and the changing life schedules of workers, the trend is to find a more even balance between one’s work and personal life.

**Pharmacists as Nontraditional Students**

Pharmacists are one population of nontraditional students that not only need to update their skills and understandings, but also their academic degree. This section provides a short history of the Nontraditional PharmD online doctoral program (NTPD), why it was created, and how it attempted to provide an online learning solution for practicing pharmacists seeking to update their pharmaceutical skills and understandings.

**Pharmacy Accreditation Mandate**

In 1997, the American Council on Pharmaceutical Education revised its accreditation standards to require the PharmD as the profession’s entry-level degree. It was decided the evolution of the pharmacy profession toward the provision of patient focused pharmaceutical care required a higher level of clinical knowledge and skills on the part of practitioners. While pharmacists practicing with a bachelor of science were “grand fathered” under the new regulations and were permitted to
continue practicing, their career movement and marketability was fundamentally
damaged because all new pharmacists entering the profession as of 2003 were
required to have the PharmD degree. These occurrences created a significant need
for postsecondary educational mechanisms to allow pharmacists to upgrade their
skills, understandings, and credentials.

Nontraditional PharmD Program

The College of Pharmacy at The Ohio State University3 launched the NTPD
program4 in January, 2001 to provide the opportunity for practicing pharmacists at
the baccalaureate level to update their pharmaceutical care skills and obtain the
PharmD degree in an online learning environment. The driving force for the online
NTPD program was the inability of most pharmacists to obtain the PharmD degree via traditional means.

The NTPD program is composed of 42 credit hours of learning modules.
These learning modules are made available to pharmacy students in an online
learning environment over 2.75 years. One new online course is introduced to
students each semester with the exception of the pharmaceutical care longitudinal
course, which spans the entire curriculum. After completing the courseware
modules, students are required to complete a series of experiential rotations. See
Table 1 for a schedule of the NTPD program curriculum.

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3 The NTPD was the first online doctoral degree program at The Ohio State University.
4 There were 41 NTPD programs among the 81 colleges and schools of Pharmacy in the United States.
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|                                   | Pharmaceutical Care Longitudinal Course: Implementing a patient-focused care model, Pharmacy practice, and the economic evaluation of pharmacy services. |

Table 1

Nontraditional PharmD Program Curriculum at The Ohio State University

This section provided a brief background of the professional pressures that led to the need for pharmacy students to update their skills and understandings. The threat to their career movement and marketability, and their inability to update their degree via traditional means led to the development of the NTPD online degree program.
Delimitations of the Study

This study had a population of 26. The study ran for one academic semester during the 2002 summer quarter. Women outnumbered men nine to four. While the 26 students had been working together in work groups for over two years and had been exposed to multiple new educational technologies since beginning their program, the potential learning benefits of concept mapping and sharing understandings with concept maps might take more a 16 week academic semester.

Summary of the Problem

Working pharmacists are required to make conceptual changes on a near continual basis. While the NTPD program was created to address an accreditation mandate, new tools and pedagogies are needed to help practicing pharmacists access their colleagues’ existing expertise and deal with large amounts of new information. This dissertation explores how collaborative learning in conjunction with a visualization of understanding tool may enable nontraditional students to more effectively share what they know in their online learning environment.

Chapter two examines the literature on social construction of understandings, conceptual change, and visualization of conceptual understandings. Chapter three describes the general methodology used for this study. Chapter four presents the results obtained with those methods. Chapter five reviews and provides a discussion of the results and proposes a new collaborative online learning community model for nontraditional students.
The integration of a new educational technology into a nontraditional online learning environment cannot be thought of only in terms of technological implementation (Zuboff, 1988). Rather the context of the learning space, including educational philosophies, community practices, conceptual change agents and a theoretical understanding of the new technology must be taken into account. The conceptual framework that supports this research is constructed in this chapter and is based on the following constructs as seen in Figure 2:

- social construction of understandings vis-à-vis collaborative learning, including a theoretical background of constructivism and online learning communities;
- conceptual change, including an exploration into students’ cognitive structures, how they manipulate them, what they do with new information, their approaches to learning and the resulting conceptual change theories; and
- visualization of conceptual understandings, supported by a theoretical base of information visualization theories, graphic organizers and concept mapping.
Figure 2. Concept map of chapter two: review of the literature.
Social Construction of Understandings

Nontraditional students need to continually update their skills and understandings with an increasing amount of new information to stay competitive in their places of work. To attempt to learn mass amounts of complex information alone is not only impractical, but ignores the existing expertise and socially constructed understandings inherent in their lived experiences. Understanding the role of social processes in learning is critical to learning as Goodenow (1992) noted:

Education is fundamentally a social and interpersonal process. Although individuals can and do learn many things through isolated observation of the world around them... for the most part what we term education occurs in the company of others (p. 177).

To understand why collaborative learning may be an appropriate pedagogy for nontraditional online learning environments, this section will examine the theoretical underpinnings of social construction of understandings including an analysis of constructivism, online learning communities and collaborative learning.

Constructivism, a theoretical base for collaborative learning and social construction of understandings, is a collection of theories about different issues in learning informed by a range of philosophical assumptions. Constructivist agendas are primarily motivated by the idea that most, if not all, knowledge domains are complex and ill-structured. Aligned with this idea are the notions that learning requires a significant degree of interaction with other students, and that learning is a kind of enculturation akin to the acquiring of language (Chomsky, 1957). Before
exploring the theoretical implications of constructivism, it is important to understand what it is not. This section first examines behaviorist and cognitivist views of learning as precursors to understanding constructivism.

Behaviorism

Behaviorists (Thorndike, 1932; Hull, 1943; Skinner, 1953) argued a student’s mind starts as a tabla rasa (i.e., blank slate), which is “written upon” by adding information through operant conditioning, which occurs when a response to a stimulus is reinforced. In the behaviorist view, knowing is a set of associations and skills. Learning is the process in which associations and skills are acquired, and transfer occurs when behaviors learned in one area are used in another. Motivation is a state of the student that favors creation of new associations and skills, primarily involving incentives for attending to a stimulus and responding positively to it (Greeno & Resnick, 1996).

If a reward or reinforcement follows the response to a stimulus, the response becomes more probable in the future. The central premise of operant conditioning is that behavior is shaped by its consequences. Desired behavior can then be shaped by arranging the reinforcement of a series of intermediate steps that lead to the target behavior. Behaviorists believe knowing can be characterized in terms of observable relations between stimuli and responses and learning in terms of forming, strengthening or weakening relations through reinforcement or non-reinforcement. Behaviorists argue by rigidly optimizing the presentation of learning material, the learning process can be optimized (Boyle, 1997). While this philosophical approach
to learning has been challenged by social cognitive and constructivist theorists in
the academe, many postsecondary educational practices still reflect behaviorist
ideals.

Moving Toward Cognitivism

Early behaviorists chose not to incorporate mental events into their learning
theories, arguing such events were impossible to observe and measure and so could
not be studied objectively. During the 1950s and 1960s, however, many
psychologists became increasingly dissatisfied with this approach to human
learning. As a result, major cognitive works began to emerge. Examples include
publications by Chomsky (1957) in psycholinguistics and by Bruner, Goodnow and
Austin (1956) in concept learning. Increasingly, cognitivism began appearing in
educational psychology literature as well including Bruner’s (1961, 1966)
scaffolding theory and Ausubel’s (1963, 1968) assimilation theory.

Cognitivism

Post-behaviorism, cognitive psychology provided the predominant
perspective within which learning research has been conducted and theories of
learning have evolved. In contrast to behaviorists, who emphasize the roles of
environmental conditions (stimuli) and overt behavior (responses) in learning,
cognitive psychologists examine how students process the stimuli (i.e., new
information) they encounter. In contrast to the behaviorist view, the cognitivist
view\textsuperscript{5} postulates the student's mind constructs conceptual frameworks, and learning consists of selecting and organizing information from a wealth of experiences to build one's knowledge base. The study of these cognitive processes includes how students perceive, interpret, and mentally store the information they receive from the learning environment. Cognitivism treats conceptual understandings as a pattern of connections between neuron like elements (i.e., concepts) and learning as the strengthening or weakening of those connections (i.e., conceptual relations). The cognitive perspective emphasizes the understanding of concepts and theories in different subject matter domains and general cognitive abilities, such as reasoning, planning and problem solving.

Cognitivists share with behaviorists the belief that the study of learning should be objective and learning theories should be developed from the results of empirical research. However, cognitivists differ from behaviorists in at least one critical respect. By observing the responses students make to different stimulus conditions, cognitivists believe they can draw inferences about the nature of the internal cognitive processes that produce those responses. This focus on information processing underlies much of cognitive theory. Cognitivism views learning as a student directed mental process of seeking, acquiring, remembering and utilizing conceptual understandings.

Learning is the result of students’ attempts to make sense of the world through encountering new information, the resulting cognitive dissonance, and their assimilating and/or accommodating the new information into their existing cognitive frameworks.

Cognitive learning is seen as "transforming significant understanding we already have rather than simple acquisitions written on blank slates" (Greeno, Collins and Resnick, 1996, p.16). In cognitive learning, information is acquired and changes in one’s conceptual framework make changes in behavior possible. Whereas in the behaviorist view, the new behaviors themselves are learned (Shuell, 1986). Both behaviorist and cognitive theorists believe reinforcement is important in learning. Behaviorists argue reinforcement strengthens responses whereas cognitivists view reinforcement as a source of information used by the student to change behavior. The cognitivist sees students as active participants who experience the world, problem solve, and reorganize their existing conceptual frameworks to achieve new insights by assimilating new information and building new conceptual links among existing conceptual understandings.

Theoretical Foundations of Cognitivism

During the height of behaviorism, the work of the Gestalt psychologists, sign learning theory, and symbolic interaction / information processing theorists laid the foundation for cognitive psychology. During the 1960s, discontent with the inadequacies of behaviorism became widespread. The behaviorist perspective could not easily explain why students attempted to organize and make sense of the
information they learned, or why students often altered the form of information they encountered. For example, verbal learning theorists originally attempted to apply a stimulus / response analysis to human language and verbal behavior, but soon discovered the complexities of human language-based learning were often difficult to explain from the behaviorist perspective (Chomsky, 1957). Increasingly, verbal learning theorists began to incorporate mental processes into their explanations of research results. Among learning psychologists there emerged a growing realization that mental events or cognition could no longer be ignored (Kendler, 1985). The following three areas were important theoretical developments in the field of cognitive psychology.

**Gestalt psychology.** During the early twentieth century, a perspective emerged in German psychology that was largely independent of the behaviorism. Wertheimer (1959) was one of the principal proponents of Gestalt psychology, which emphasized higher order cognitive processes. Gestalt psychologists\(^6\) emphasized the importance of organizational processes in perception, learning, and problem solving and argued students are predisposed to organize information in particular ways.

The focus of Gestalt theory is the idea of "grouping," that is, characteristics of stimuli causes students to structure or interpret a learning problem in a particular way. The primary factors that determine grouping are: *proximity*, concepts tend to be grouped together according to their nearness; *similarity*, concepts similar to other

\(^6\)Gestalt psychology was advanced by such theorists as Wertheimer (1945, 1959), Kohler (1929, 1947, 1959, 1969) and Koffka (1935).
concepts tend to be grouped together; closure, concepts are grouped together if they tend to complete some entity; and simplicity, concepts will be organized into simple figures according to symmetry, regularity and smoothness. Further, Werthiemer (1959) suggested the essence of successful problem solving behavior is being able to see the overall structure of the problem:

A certain region in the field becomes crucial, is focused; but it does not become isolated. A new, deeper structural view of the situation develops, involving changes in functional meaning, the grouping, etc. of the items. Directed by what is required by the structure of a situation for a crucial region, one is led to a reasonable prediction, which like the other parts of the structure, calls for verification, direct or indirect. Two directions are involved: getting a whole consistent picture, and seeing what the structure of the whole requires for the parts (p. 212).

Extending Werthiemer’s (1959) line of reasoning, mid-career students may need to see the overall structure of their conceptual frameworks before they can incorporate new concepts or conceptual relations into their frameworks. When important information is isolated, students can view how concepts are related, and this makes the overall conceptual framework more easily understood (Novak & Gowin, 1984). Omitting extraneous information and presenting only what is essential simplifies the learning task. This theoretical approach to learning might provide support for depicting conceptual frameworks as it allows students to view the overall structure of their existing conceptual understandings, as well as how new information can fit into their existing conceptual frameworks.
Learning implications derived from Gestalt theory include students should be encouraged to discover the underlying conceptual relations of a knowledge domain and that gaps in a student’s understanding are an important stimulus for learning. Finally, educational design might be based upon the Gestalt laws of organization including proximity, closure, similarity and simplicity.

Sign learning theory. Tolman (1932, 1938, 1948, 1959) was a prominent learning theorist during the height of the behavioral movement, yet his work had a distinctly cognitive flair. Tolman's sign learning theory has been called “purposive behaviorism” and is often considered the bridge between behaviorism and cognitivism. According to Tolman's theory, an organism learns by pursuing signs to a goal. That is, learning is acquired through meaningful behavior (Tolman, 1948). Tolman argued learning is always purposive and goal-directed, learning often involves the use of environmental factors to achieve a goal, and organisms will select the shortest or easiest path to achieve a goal.

Tolman's version of behaviorism emphasized the relationships between stimuli rather than between stimulus and response. According to Tolman, a new stimulus (the sign) becomes associated with already meaningful stimuli (the significate) through a series of pairings. Therefore there is no need for reinforcement in order to establish learning. This idea was the foundation of schema and scaffolding theories as well as a host of conceptual change theories.
Symbolic information processing theory. The symbolic information processing approach to cognitive theory encompasses a dynamic and rapidly changing view of how students acquire, process, store and retrieve information. Symbolic information processing was developed by many researchers including Chomsky (1957) and Newell and Simon (1972) and is focused on characterizing processes of language understanding, reasoning, and problem solving. Case (1992) classified symbolic information processing as an empiricist tradition because of its focus on knowledge as a set of associative networks and procedures. Symbolic information processing emphasized the organization of information in cognitive structures and the processes by which students access, manage and change these structures.

Although there are differences of emphasis between these theoretical traditions, they share important assumptions. All three theories (Gestalt psychology, sign learning theory, and symbolic information processing theory) emphasized the importance of organized patterns in cognitive activity. Learning was understood as a constructive process involving reorganization of concepts in the student’s conceptual framework and growth in general cognitive abilities based on these reorganizations. Cognitive theorists emphasized that motivation in learning often occurs without the need for extrinsic incentives, as in the case of learning one’s first language (Greeno & Resnick, 1996), and instead focused on ways to foster the intrinsic interest of students to reorganize their existing conceptual frameworks.
Constructivism

Even though there is no single constructivist theory\(^7\), constructivism's central idea is that learning is constructed and students construct new understandings upon the foundation of existing knowledge. This view of learning sharply contrasts with the behaviorist view in which the teacher rigidly structures both learning materials and processes.

Two important notions support the idea of constructed conceptual understandings. The first is students construct new understandings using what they already know. That is, students’ minds are not blank slates on which new information is etched. Rather, students come to their learning environments with complex conceptual frameworks constructed from previous experiences. These existing conceptual frameworks influence what new or modified conceptual understandings.

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\(^7\) Even though there is no single constructivist theory, many constructivist theories suggested: the student, through interacting with the world, actively constructs, tests and refines cognitive frameworks (Boyle, 1997; Cunningham, 1992; Hein, 1991; Jonasson, 1992; Merrill, 1991); learning (not teaching) is the focal issue while the teacher's role is to guide students to make connections between concepts and foster new conceptual relations (Boyle, 1997; Bruner, 1973; Hein, 1991); learning is a search for meaning and meaning requires understanding wholes as well as parts (Boyle, 1997; Hein, 1991; Merrill, 1991); students should be aware of their mental models of the world and the assumptions they make to support those models (Boyle, 1997; Cunningham, 1992); assessment is not a separate activity, but part of the learning process (Boyle, 1997; Perkins, 1991; Wilson, 1986); instruction should be designed to facilitate exploration and go beyond the information given (Bruner, 1973); learning should take place in a social process which encourages dialogue with other students and experts (Brooks, 1993; Hein, 1991); students learn in relation to prior knowledge and our learning environment. Student's prior conceptual understandings should be established before teachers scaffold learning environments (Hein, 1991; Ausubel, 1963, 1978); for significant learning to occur ideas must be revisited (e.g., spiral design) (Hein, 1991; Bruner, 1973); motivation is a key component to learning (Hein, 1991; Pintrich et al., 1993; Pintrich & Schunk, 1996; Schunk, 1991; Pajares, 1997); provide multiple representations of reality, thereby, avoiding over simplification of learning by representing the natural complexity of the world (Cunningham, 1992; Jonasson, 1992; Perkins, 1991; Wilson, 1986); supports collaborative learning through social construction of knowledge and shared responsibility for learning (Brown, 2000; Jonasson, 1992; Perkins, 1991; Hein, 1991); reflection through iterative self-assessment is a key competent in developing expert students (Jonasson, 1992; Wilson, 1986); learning with informing technologies (Green, 2000, Maxwell & McCain, 1996, Zuboff, 1988); and exploring students’ learning styles (Gardner, 1983; Kolb, 1984).
understandings students will construct from new information. The second is students
do not merely discover knowledge through simple observation; they actively and
purposefully construct it (Merrill, 1991). The student selects and transforms
information, constructs hypotheses, and makes decisions relying on an existing
cognitive structure to do so. Cognitive structure (e.g., schema, mental models,
conceptual frameworks) provides meaning and organization to experiences and
allows students to add to and reconstruct existing cognitive structure. These
cognitive constructions are continually modified and refined as new information is

Constructivism can be divided into three main categories: psychological /
individual, social, and sociological. Psychological / individual constructivists are
concerned with how individuals make sense of their world (Piaget & Inhelder,
1969). Social constructivists argue social interaction shapes individual development
and learning (Vygotsky, 1978) vis-à-vis social processes (Woolfolk, 2001).
Sociological constructivists are interested in how social understandings are
constructed as well as how existing social constructions of knowledge are
communicated to members of a learning community (Gergen, 1997).

Psychological / Individual Constructivism

Psychological constructivists are concerned with how individuals build their
individual cognitive abilities. Cognitive development theory provides the theoretical
basis for psychological constructivism.
**Cognitive development theory.** Piaget and Inhelder (1969) proposed a sequence of cognitive stages through which students pass. Cognitive abilities at each stage build on and incorporate previous stages as they become more organized and adaptive and less tied to concrete events. They described how cognitive structure changes through the processes of adaptation vis-à-vis assimilation and/or accommodation and equilibrium. Assimilation takes place when students use their existing knowledge to make sense of new information by fitting it into their existing cognitive structure. Accommodation occurs when a student must change existing cognitive structure to accommodate new information that does not fit into her existing conceptual framework. Once assimilation or accommodation has occurred, there is a reconceptualization or reorganization in the student’s cognitive structure. For students, this reorganization is an ongoing process of arranging information and experience into existing cognitive structures by adding and relating new concepts and adjusting existing cognitive structure as necessary to accommodate new concepts and conceptual relations.

Based on the outcomes of assimilating and accommodating new information, the actual change in understanding takes place in the process of equilibrium when the student attempts to make sense of how the new information fits (or does not fit) into her existing conceptual framework. If new cognitive structure is developed or concepts within existing conceptual frameworks develop new relations, learning has occurred. If a student easily incorporates new information into her existing cognitive structure, equilibrium is achieved. If new information does not fit easily
into her existing cognitive structure, disequilibria occurs and the student strives for equilibrium through additional assimilation and/or accommodation. Thus her thinking changes and she has to develop a revised conceptual framework. Again, learning has occurred.

For psychological constructivists, cognitive development consists of students’ constant effort to adapt to learning environments in terms of assimilation and accommodation. Cognitive development is therefore facilitated by providing activities or learning scenarios that engage students with new information that challenges students existing interpretations to force disequilibria and subsequent conceptual reconstructions. Piaget saw the social environment as an important factor in cognitive development, but did not believe social interaction was the main mechanism for conceptual change (Moshman, 1982).

Social Constructivism

Social constructivists base their theories on two fundamental principles. First, learning requires intellectual challenges to students’ existing conceptual understandings. Second, these challenges are best aroused in dialogue with other students (Johnson & Johnson, 1990). Social constructivists suggest students learn and experience higher levels of learning when they are stimulated by authentic activities in which they reason, explore, resolve problems, and reflect on their conceptual change processes with other students. The following four theories provide the foundation for social constructivism.
Social development theory. Researchers realized learning was a complex social process that went beyond mere transmission of knowledge, and as a result, began to explore how communication, social interactions, educational technologies and learning environments contributed to cognitive development. This line of inquiry was guided by Vygotsky’s (1978) social development theory, which argues social relationships underlie all higher cognitive functions.

A major theme of Vygotsky's (1978) theoretical framework was social interaction plays a fundamental role in the development of cognition. Vygotsky (1978) stated: "Every function in the [student’s] cultural development appears twice: first, on the social level, and later, on the individual level. First, between people (interpsychological) and then inside the [student] (intrapsychological)" (p.57). According to Vygotsky, students are capable of performing at higher cognitive levels when asked to work in collaborative situations than when asked to work individually. Vygotsky argued that social interaction, cultural tools, and activity shapes individual cognitive development and learning. Further, by participating in activities with others, students appropriate the articulations constructed socially and “acquire new strategies and knowledge of the world and culture” (Palincsar & Brown, 1998, p. 351). In other words, group diversity in terms of knowledge and experience can contribute positively to the social learning process.
A second aspect of Vygotsky's (1978) theory is his idea that the potential for cognitive development is limited to a certain space/time span. The zone of proximal development is the space/time where/when a student can solve a learning problem with the structured assistance (e.g., scaffolding) of a teacher or a more experienced student. A similar idea based on Piaget's work was called the “problem of the match.” A student must be neither too bored by learning tasks that are too simple, nor be left behind by tasks too difficult.

Social learning theory. Bandura’s (1971) social learning theory is a neo-behavioral theory that expands on behaviorist views of reinforcement and punishment. In behaviorism, reinforcement and punishment directly affect students’ behavior (Woolfolk, 2001). With social learning theory, Bandura demonstrated students can learn by observing the actions and consequences to those actions of other students.

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8 This point is particularly interesting in an online learning environments where students are not face-to-face and are often moving through new information at their own pace. Does "at their own pace" allow students to maintain their own "match" and regulate themselves so they maintain their optimal position in their zone of proximal development? If students have a better sense of when they are ready to advance through the course than are teachers, self-paced learning (on or offline) may not complicate the problem of the match. This question is beyond the scope of this study.

9 Key points in Bandura’s social learning theory include: (1) the highest level of observational learning is achieved by first organizing and rehearsing the modeled behavior symbolically and then enacting it overtly; (2) students are more likely to adopt a modeled behavior if it results in outcomes they value; and (3) students are more likely to adopt a modeled behavior if the model is performed by someone of higher status and the behavior has functional value (Bandura, 1986).
He argued behavioral views provide only a partial explanation of learning and overlook important elements, particularly social influences on learning. Bandura (1977) stated:

Learning would be exceedingly laborious, not to mention hazardous, if [students] had to rely solely on the effects of their own actions to inform them what to do. Fortunately, most human behavior is learned observationally through modeling; from observing others, one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action (p. 22).

In short, if a student observes a respected peer student succeed, the student will likely model the successful behavior. In addition to Vygotsky’s (1978) social development theory, Bandura’s (1971) social learning theory provides a theoretical base for collaborative learning as a necessary pedagogy for continually updating one’s understandings.

Social cognitive theory. In his book *Social Foundations of Thought and Action: A Social Cognitive Theory*, Bandura (1986) advanced the notion that students possess beliefs that enable them to exercise a measure of control over their thoughts, feelings, and actions. Social cognitive theory emphasizes students learn by observing others (vicarious learning) as well as by doing and experiencing the consequences of their own actions (enactive learning). If students can learn by watching, he argued, they must be focusing their attention, perceiving,

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10 Bandura (1986) noted there are four important elements in observational learning: (1) paying attention, (2) retaining information, (3) producing behaviors, and (4) being motivated to repeat the behaviors.
remembering, thinking, and problem solving which affects their learning. As such, much is going on cognitively before performance and reinforcement can even take place. Bandura’s social cognitive theory also asserts that observable performance (behavior) and the acquisition of knowledge (learning) are distinct. In other words, students may possess knowledge they are unwilling or unable to demonstrate. In other words, students may know more than they show (Woolfolk, 1998).

A related sub-theory of social cognitive theory is *reciprocal determinism* (Bandura, 1986). Personal factors (beliefs, attitudes, and existing notions), the physical and social environment (resources, peers, and learning environment), and behavior (actions, choices, and verbalizations) all influence and are influenced by each other. That is, the learning environment and the student reciprocally determine the other. Students are neither completely driven by inner forces (cognitive perspective) nor automatically shaped and controlled by external stimuli (behaviorist perspective). Rather, “learning is explained in terms of a model of triadic reciprocity in which behavior, cognitive, and environmental factors all operate as interacting determinants of each other” (p. 18). If personal factors, behaviors, and the learning environment are in constant interaction, and students may “know more than they show,” then understanding students’ construction of knowledge in collaborative online learning environments requires both educational designers and teachers understand how these factors interact and affect students’ conceptual change processes.
Self efficacy theory. Bandura (1986) argued that self efficacy, "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (p. 391), is an important arbiter in student agency and plays a powerful role in determining the choices students make. Self efficacy also affects students’ level of motivation, how long they will persevere in difficult learning scenarios, and the degree of anxiety and/or confidence they will bring to the learning environment. Bandura argued it is self efficacy that explains why students’ behavior differs widely even when they have similar knowledge and skills in a particular domain.

The effect of self-reflexivity depends on the relationship among three key elements students bring to learning moments: students’ conceptual understandings, their self efficacy beliefs, and their outcome expectations. Bandura argued self efficacy is a stronger predictor of behavior than either outcome expectations or existing understandings, but the relationship among the three components is complex (Woolfolk, 2001). For example, Pajares (1997) suggested students with high self efficacy in a specific knowledge domain tend to persist longer and are motivated to set higher learning goals in complex learning situations.

This self-reflective capability, wrote Bandura, is the one characteristic that is most "distinctly human" (1986, p. 21), for it permits students to reflect on and evaluate their own learning experiences and conceptual change processes. Control over one’s self efficacy provides the potential for self-directed change and the ability to influence behavior. The degree to which students affect their behavior,
however, involves the accuracy of their self-observation, choices they make regarding these observations and self-reflexive reactions to their own learning behavior\textsuperscript{11}. Self efficacy is important to students learning a new technology because it represents an important dimension of perceived control over one’s learning environment. This is especially critical for online nontraditional students as their perceptions of how successful they will be is influenced not only by their past experiences with educational, work, and play technologies, but because their learning environment is completely online.

When implementing a new educational technology and a new pedagogical approach into a nontraditional online learning environment, it may be important to understand students’ self efficacy of both their ability to learn and use the new educational technology. Closely associated with students’ self efficacy with a new educational technology is their experience with and subsequent tacit understanding of working with abstract, constructed conceptual relations in a networked, online learning environment. McCain et al. (1999) found students who received hands-on experience with online learning technologies improved their overall sense of control, creativity and efficacy with these technologies.

\textsuperscript{11} What is missing from these analyses is a discussion of how a community of students can assist one another not only in communicating their conceptual understandings, but also in sharing beliefs in their ability to restructure their existing conceptual understandings. This question goes beyond the scope of this dissertation.
Sociological Constructivism

Sociological constructivists are interested in how tacit knowledge, everyday beliefs, and commonly held understandings about the world are communicated to new members of a socio-cultural group (Gergen, 1997). This theoretical approach leads to learning communities, social construction of knowledge and subsequent social understandings. The sociological constructivist perspective views understandings as distributed among students and their learning communities. Analyses of activity from this perspective focus on processes of interaction\(^{12}\) of students with other students and teachers.

Sociological constructivism provides for a synthesis of behaviorism and cognitivism. While behaviorists study processes of activity, neglecting their contents, cognitivists analyze concepts of cognitive activity, including conceptual change processes that transform those concepts, but neglect processes that must be included if activity is to be understood as being social (Greeno & Resnick, 1996). According to this analysis, behaviorism, cognitivism and sociological constructivism may constitute a kind of Hegelian cycle of thesis-antithesis-synthesis (Greeno & Moore, 1993), in which behaviorism provides a thesis that focuses on external aspects of activity, the cognitivist view provides an antithesis that focuses on internal conceptual processing aspects, and the sociological constructivist view may develop as a synthesis that unites the strengths of behaviorism and cognitivism.

\(^{12}\) “Interactive” is a close synonym for the concept “situative” (Bickhard & Richie, 1983). Ethnography, the study of cultural practices and patterns of social interactions, is an example of a situative methodology.
While psychological and social constructivism each provide theoretical foundations for conceptual change and collaborative learning, sociological constructivism provides the strongest rationale for social construction of understandings in learning communities. As such, three supporting sociological constructivist theories are examined to further explore social construction of understandings in collaborative learning communities.

**Authentic learning.** Gardner (1991) suggested the reason new information often seems irrelevant to students is because it is not presented in a context the student can understand. Nontraditional students’ ability to understand new information is especially sensitive to their ability to bring the new concepts to bear in their professional workplace. Adult students need to know why they need to learn something. They need to learn experientially, approach learning as problem-solving, and be involved in the planning and evaluation of their learning. Most important, their prior experiences provide the basis for learning activities and they learn best when the topic or skill is scaffolded around *authentic* problems that can be solved and applied immediately to the students’ professional life. Authentic learning is therefore dependent on teachers situating new information in terms of students’ lived experiences (Richter, Maxwell & McCain, 1995; Means, 1994).

**Situated learning.** Lave and Wenger (1991) argued learning is a function of the activity, context and culture in which it occurs (i.e., it is situated). This contrasts with most classroom learning activities, which involve interpretations of ideas that are often abstract and out of context. At its most basic level, “situated
learning...emphasized the idea that much of what is learned is specific to the situation in which it is learned” (Anderson, Reder, & Simon, 1996, p. 5). The principle ideas of situated learning are: (1) new information needs to be presented in an authentic context (i.e., educational settings and applications that would normally involve those understandings), and (2) learning requires social interaction and collaboration. Social interaction is a critical component of situated learning as students become involved in a learning community, which require students to acquire other students’ practices and interpretations. Learning, both outside and inside school, advances through collaborative social interaction and the social construction of understandings in situated learning environments (Brown, Collins & Duguid, 1989). Knowledge is not seen as a block of information owned by only one student, but is a social construction created and shared by a learning community. The communal practices, skills, and tools constitute the conceptual understandings of a learning community. Situated learning requires developing skills to engage learning situations in one’s learning community (Greeno, Collins & Resnick, 1996). Researchers who emphasized the social construction of understandings and situated learning affirm Vygotsky’s (1978) notion that learning is inherently social and is situated in a particular cultural setting.

13 Other research has further developed the theory of situated learning. For example, cognitive apprenticeships (Collins et al., 1989) support learning by enabling students to acquire, develop and use cognitive tools in authentic learning activities.
Functional context. Sticht (1976, 1988) argued for a functional context approach to learning which stresses the importance of making learning relevant to students’ professional lives. Sticht suggested the learning of new information is facilitated by making it possible for students to relate new information to existing knowledge bases if the information is contextualized to fit students’ professional experiences. For example, by incorporating educational materials in both their learning environments and professional practice, students’ transfer of new information from the classroom to their workplace might be enhanced. Functional context theory is directly related to authentic learning and situated learning theories. All three theories emphasize teachers should understand both students’ understandings and their authentic learning needs. With more explicit representations of students’ existing conceptual understandings, teachers may be able to more effectively design authentic learning activities relevant to nontraditional students’ professional practices.

Sociological constructivism provides the conceptual foundation for exploring online learning communities as a milieu within which nontraditional students might share their expertise and understandings with other students.

Collaborative Learning Communities

Some researchers have suggested collaborative learning in learning communities facilitates social construction of understandings (Grubb & Hines, 2000; Stacey, 1999). Some scholars identify learning communities by their outcomes, while others classify them by the design of the online learning
environment (Stein & Wheaton, 2001). This report defines learning communities as collaborative learning spaces where students, teachers and learning resources interact to socially share existing understandings and construct new knowledge.

According to Palloff and Pratt (1999), creating learning communities helps create an empowering and rich learning environment. Learning communities encourage multi-way dialogue among students and teachers to promote collaborative learning evidenced by student-to-student sharing of ideas. Students presenting what they know publicly further facilitates the sharing of knowledge. These public presentations are peer reviewed by the learning community. If the presented knowledge is useful, all members of the community benefit from the newly constructed shared understandings.

Just as technology mediates communication as a function of the technologies affordances (Innis, 1951), nontraditional students need to understand the learning possibilities and implications of learning in a learning community (see Figure 3). A learning community might facilitate social construction of understandings in four iterative stages. First, students discover new concepts and conceptual relations. They assimilate and/or accommodate the new information and restructure their conceptual frameworks individually. Second, students share their new conceptual understandings with others in the learning community. Third, students peer review, critique and restructure the new understandings vis-à-vis community dialogue. A learning community either validates the propositional claims hypothesized in students’ shared understandings or discards them. And fourth, if the new
understandings are accepted, the learning community uses the new understandings as part of its existing conceptual framework to acquire new information.

Figure 3. Social construction of understandings in collaborative learning communities.
Stacey (1999) further argued a learning community was “achieved through the development of a group consensus” of knowledge through communicating different perspectives, receiving feedback from other [students] and [teachers], and discussing ideas until a final negotiation of understanding was reached” (p. 31). The assumptions students make, their beliefs, and experiences shape what they come to “know” about the world. It follows that different assumptions and different experiences lead to different understandings. Constructivists stress the importance of understanding the knowledge construction process so students will be aware of the influences that shape their thinking. This understanding enables students to choose, develop, and defend positions in a self-critical way while respecting the positions of others. Students must learn to share diverse ideas in the heterogeneous, global workplace. Students will work with others who have different educational and theoretical backgrounds, and yet they will have to find shared meaning if they are to succeed. The act of social negotiation during social construction of knowledge requires students understand where their colleagues are “coming from.” Before students can share meaning on new abstract ideas, they must first explicitly understand and be able to show how they construct their existing understandings and how they understand their own conceptual change processes.

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14 Stacy also argued that dialogue in sub-groups established a “secure zone” for students to construct conceptual understandings and present their individual conceptual understandings to their peers before committing their ideas to the larger group (1999, p. 24).
Understanding in Learning Communities

Understanding, in a sociological constructivist perspective, is to understand how groups of students carry out collaborative activities and how individual students join and participate in learning communities. Online learning communities are composed of students, social constructions of understanding and the dialogic practices and rules that enable online learning communities to function (Greeno & Resnick, 1996). The practices of an online learning community, and the boundaries determining membership, provide rules that organize a community’s activities and the participation of students who are capable of following and/or manipulating those rules. Through experience, a learning community develops a shared understanding of its rules and procedures and how it relates to other learning communities.

Learning socially in a learning community involves becoming attuned to the boundaries and affordances of technological and social systems of the community. The processes of developing social understandings and the rules of the community are significantly interdependent.

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15 Nickerson (1985) suggested: “understanding is an active process. It requires the connecting of facts, the relating of newly acquired information to what is already known, the weaving of bits of knowledge into an integral and cohesive whole. In short, it requires not only having knowledge but also doing something with it... [Nevertheless] all understanding is tenuous and, in a sense, transitory. We are obliged to understand the world in terms of the concepts and theories of our time... At root, understanding is a true paradox: the more one learns,... the more one ... (becomes) aware of the depth of one’s ignorance. [And yet] if understanding is a primary goal of education, an effort to understand understanding would seem to be an obligation, even if ... (it is) only a partially successful effort” (pps. 217, 234, 236).

16 Communities’ social practices have traditionally been studied by anthropologists and sociologists (Hutchins, 1995).
Collaborative learning develops the understandings, which can reciprocally change the rules and extend the learning community by removing barriers to entry and inviting new students to join. In short, social constructions of understanding and community practices are interdependent and mutually defining.

Membership and participation. Online learning communities often include apprenticeship and other forms of being initiated into a learning community. Lave and Wenger (1991) reviewed several studies of learning involving apprenticeship and concluded that a crucial factor was students must be afforded “legitimate peripheral participation,” which involved access to the practices they are expected to learn in order to gain access to the central practices of the learning community. Lave and Wenger (1991) characterized learning of practices as processes of community participation in which new students are relatively peripheral in observing and practicing activities of a learning community. As students became more experienced, their participation became more central. A critical starting point for online learning communities is to allow new students to "lurk" on the side of interactions in which they are not taking part and in online learning communities of which they are not members.

\[17\] Motivation came from students working toward building their individual identities in relation to the community goals (Rheingold, 1993) and was enhanced or diminished by the student’s participation in central community activities.
Lave and Wenger (1991) also demonstrated how active training programs fail once new students are cut off from experienced practice in their learning community. The implications of their findings suggested training nontraditional students in both the use of new educational technologies and new pedagogical learning methodologies should not end with an initial treatment, but rather continue as a structured part of students’ technological and pedagogical training.

**Leveraging Social Construction of Understandings**

Brown (2000) compared knowledge to an iceberg in that what students “know” is the tip of the iceberg and what they “don’t know” is the 99 percent of the iceberg under the waterline that they cannot see and, more important, cannot directly access. Furthermore, the bulk of what is known and under the waterline is known by others and is tacit understanding embedded in students’ professional lives and practices. This picture of knowledge embedded in individual practice and learning communities does not dismiss individual knowledge. What students can access through membership in a community of learning, however, is not as much individual as shared, partial knowledge (Brown, 2000). Individual and social knowledge in this view are interdependent much like a single bicyclist on the Tour de France U.S. Postal Service team, a cellist to the overall symphony or the quarterback to the entire offensive squad. Each actor may know how to execute her individual part to perfection, but on its own, that part does not provide for either individual success or for the success of the larger community. As an individual, the part is significantly incomplete for it requires the group to make sense of it.
Knowledge is typically thought of as a possession of individuals, something students own and may choose to share with others. Declarative knowledge is, to an extent, like this. Procedural knowledge and tacit knowledge, however, are different. Procedural knowledge enables students to put declarative knowledge into practice, and this is critical in making knowledge actionable and operational. Tacit knowledge, the non-explicit social practices associated with one’s learning community, explains the deeper knowledge that comes only with experience (Nonaka & Takeuchi, 1995). Tacit knowledge is only obtained by acting on and with the world. “Experience at work creates its own knowledge. And as most work is a collective, collaborative venture, so most dispositional knowledge is intriguingly collective, less held by individuals than shared by work groups. This view of knowledge as a social property stands at odds with the pervasive ideas of knowledge as individual” (Brown & Duguid, 1989, p. 6).

A capable student is not only one who knows in the abstract how to act in particular learning environments, but who in practice can recognize the rules, boundaries and practices of an online learning community, and act appropriately when they occur (Brown & Duguid, 1996). That disposition\(^\text{18}\) only reveals itself, however, when the learning situation occurs. Brown (2000), a chief research scientist at PARC XEROX, studied XEROX’s copy machine service technicians. For the most part, these technicians worked alone at customers’ offices with only

\(^{18}\) Such dispositional knowledge is not only revealed in practice but is created out of practice. That is, dispositional knowledge is, to a great extent, the product of experience and the tacit knowledge experience provides. Dispositional knowledge differs from conditional knowledge in that it is not explicitly known by the student, but rather is an unconscious tendency or indication to act (Brown & Duguid, 1996).
“fix-it” documentation, their individual knowledge, and phone access back to the main service office. They would seem to be the last people to have collective dispositional knowledge. Yet the study revealed these technicians took great pains to spend time and dialogue with one another at lunch or over coffee. During these sessions, the technicians shared their experiences and problems from the field that they could not individually solve. In the process of this collaborative dialogue, the technicians added to and drew from the technician community’s social constructions of understandings. This example suggested that even for individual students with complex conceptual frameworks, collaborating with one’s peers in a learning community may mean the difference between success and failure. It also suggested collaborative learning is a necessary condition for social construction of understandings.

**Collaborative Learning**

“Collaboration,” derived from its Latin root, means “to work, one with another.” Collaborative learning has a long history in American education. In the early 1900s, Dewey (1938) criticized the use of competition in education and encouraged educators to structure schools as democratic learning communities. Dewey challenged foundational teaching of the classics at the turn of the century and instead recommended teachers design learning environments where students could learn collaboratively and not competitively.
Nelson-LeGall (1992) captured the nature of collaborative learning:

Learning and understanding are not merely individual processes supported by the social context; rather they are the result of a continuous, dynamic negotiation between the individual and the social setting in which the individual's activity takes place. Both the individual and the social context are active and constructive in producing learning and understanding (p.52).

Collaborative learning is student centered\(^\text{19}\) and distributes the authority and responsibility for both learning and the community’s actions among the members of the learning community. Collaborative learning is dialogic and is multi-modal. It focuses on including the diverse opinions of all students in the learning community and respecting each of them for their unique contribution to the learning problem. Collaborative learning encourages students to self-assess and iteratively evaluate their individual and community learning products, community processes and relationships. The underlying premise of collaborative learning is based on consensus building through cooperation\(^\text{20}\) by community members. This is in contrast to competition, in which individuals seek to best other community members. Collaborative learning is also a personal learning philosophy. In all situations where students come together in communities, it suggests a way of dealing with students, which respects, highlights and publicly applauds individual

\(^{19}\) Collaborative learning is, "a pattern in which the primary focus of [students’] action and attention is each other. Teachers teach for the most part indirectly through reorganizing [students] socially and designing appropriate tasks" (Bruffee, 1993, p. 31).

\(^{20}\) Bruffee (1993) saw the difference between cooperative and collaborative learning on a continuum beginning with cooperative learning and moving toward collaborative learning. He argued that students first learn how to cooperate; that is, they learn the community processes needed to complete a learning task with other students. After automating this knowledge, the student may move into incorporating a collaborative philosophy of learning.
students’ abilities and contributions. Moreover, collaboration is a philosophy of interaction where students are responsible for their actions, including learning and respecting the abilities and contributions of their peers. There is a sharing of authority and acceptance of responsibility among group members for the groups’ actions.

**Research on Collaborative Learning**

The effectiveness of collaborative learning has been well established in the research literature. In a meta-analysis of over 120 studies, collaborative learning...

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21 Researchers have found collaborative learning: promotes student centered learning (Felder, 1997); helps teachers move to student centered learning (Hertz-Lazarowitz, 1992); encourages student responsibility for learning (Baird & White, 1984); promotes exploratory learning (Slavin, 1990); stimulates critical thinking (Johnson, 1973, 1974); develops higher order thinking skills (Webb, 1982; Schwartz, Black, Strange 1991; Johnson, D. 1971; Cooper, et al. 1984; Slavin, 1992; O'Donnell et al., 1988); encourages diversity of understanding (Burnstein & McRae, 1962; Swing & Peterson 1982; Hooper & Hannafin, 1988); fosters interpersonal relationships (Johnson & Johnson, 1987); explores alternate conceptual understandings in a safe learning environment (Sandberg, 1995); develops social interaction skills (Johnson, Johnson & Holubec, 1984; Cohen & Cohen, 1991); enhances self management skills (Resnick, 1987); builds self-esteem in students (Johnson & Johnson, 1989; Kagan, 1986; Webb, 1982); enhances student satisfaction with learning (Turnure & Zeigler, 1958); significantly reduces classroom and test anxiety (Kessler, Price & Wortman, 1985; Johnson, Johnson & Holubec, 1989); increases students’ chances of finishing assignments (Felder, 1997; Johnson & Johnson, 1990; Deutsch, 1949; Marzano, 1992; Costa & O'Leary, 1992); increases student retention (Astin, 1977; Garibaldi, 1976; Treisman, 1985); fosters metacognition in students (O'Donnell & Dansereau, 1992; Hertz-Lazarowitz, Kirkus & Miller, 1992; Pressels, 1992; Costa & O'Leary, 1992; Webb, 1985; Weinstein et al., 1989; Yager, et al., 1985, 1986; Johnson, Johnson & Holubec, 1992); improves problem solving strategies (Bruner, 1985); promotes a positive attitude toward the subject matter (Bligh, 1972); fosters team building and a team approach to problem solving while maintaining individual accountability (Cooper et al., 1984; Johnson, Johnson & Holubec, 1984; Slavin, 1983); involves students in developing curriculum and class procedures (Kort, 1992; Meier & Panitz, 1996; Marzano, 1992); stimulates critical thinking and helps students clarify ideas through discussion and debate (Peterson & Swing, 1985; Nelson-LeGall, 1992; Brown & Palinscar, 1989); fosters students developing responsibility for each other (Bonoma et al., 1974); models problem solving techniques by students’ peers (Bandura, 1986; Schunk & Hanson, 1985; Levin, Glass & Meister, 1984; Bargh & Schal, 1980); allows students to view learning scenarios from others’ perspectives (development of empathy) (Yager et al., 1985; Johnson, 1975; Webb, 1980; Johnson & Johnson, 1985); promotes innovation in teaching and classroom techniques (Slavin, 1980, 1990; Bean, 1996); promotes social and academic relationships well beyond the course (critical in online learning environments to avoid students’ feelings of isolation) (Bean, 1996; Felder, 1997; Johnson and Johnson, 1987; Cohen & Willis, 1985; Cooper et al., 1984; Cohen & Willis, 1985; Kessler & McCleod, 1985); allows weaker students to improve their academic
was compared to learning where competition or individual success was the focus (Johnson & Johnson, 1993). In achievement across math, verbal and procedural tasks, collaborative learning was consistently superior. Research on academic achievement also found that high levels of collaboration promoted higher levels of intrinsic motivation, deeper conceptual change and greater retention of the skills learned (McCain & Maxwell, 2001). For a comprehensive web site on collaborative learning processes in online learning communities, see Green’s (2002) Online Pedagogy Connected Education Portal web site at: http://virtual.pharmacy.ohio-state.edu/Cable/cable/pedagogy/default.htm.

Beneficial to high academic achievers. Collaborative learning is beneficial to low achievers when they are grouped with higher achievers because the higher achievers teach them (Cohen, 1994). Collaborative learning provides high achievers with deeper understanding that comes only from teaching material. The process of explaining one's rationale creates a higher level of comprehension and promotes critical thinking skills (Johnson, 1973, 1974; Swing & Peterson, 1982). Favorable effects of students teaching other students may stem from what Felder (1997) called cognitive facilitation. In studies on the nature of interactions in collaborative learning, Cohen (1994) reported the most consistent, positive predictor of performance when grouped with higher achieving students (Cohen, 1994; Swing & Peterson, 1982; Hooper & Hannafin, 1988; Felder, 1997; Burns, 1990; Johnson & Johnson, 1990; Vygotsky, 1978); provides stronger students with the deep understanding that comes only from teaching material (i.e., cognitive rehearsal) (Craik & Lockhart, 1972; Felder, 1997; Cohen, 1994; Webb, 1983, 1991; Swing & Peterson, 1982); promotes positive social responses to problems and fosters a supportive environment within which to manage conflict resolution (Sherman, 1991; Messick & Mackie, 1989); provides the foundation for developing learning communities (Tinto, 1997); and encourages students to seek help and accept tutoring from their peers (Hertz-Lazarowitz et al., 1992; Beller, 1955; Cook & Pelfrey, 1985; Nelson-LeGall, 1992; Webb, 1992; Veeder, 1985).
achievement in these studies was the giving of detailed, elaborate explanations (Webb, 1983, 1991). In other words, the student who did the explaining was the student who benefited, controlling for how well the student would have done based on past achievement / ability. Further, Webb and Palincsar (1996) found giving good explanations appeared to be even more important for learning than receiving explanations.

Students are often better teachers to other students than the teacher because students had not yet “chunked” the knowledge construction and conceptual change processes (Chase & Simon, 1973) of complex understandings. Students who had just learned a concept had to struggle with it, reconceptualize their existing conceptual frameworks, encountered disequilibria and cognitive dissonance and finally incorporated the new concept into their conceptual understandings have the learning steps still explicit and fresh in their minds. This struggle process is what other students need to understand. Experts (i.e., teachers) had struggled with these ideas years ago and had since “chunked” the knowledge and may no longer be able to explicitly describe the step-by-step processes of learning the new information.

Problems with Collaborative Learning

McCaslin and Good (1996) listed several disadvantages of collaborative learning including: (1) students often value the processes or procedures of collaborative learning over the learning goals, (2) speed and finishing can take precedence over thoughtfulness and meaningful learning, (3) socializing and interpersonal relationships may take precedence over learning and students may
simply shift dependency from the teacher to the “expert” in the group, (4) learning may still be passively transmitted and what is learned from other students can be less than accurate, (5) status differences among students may be increased rather than decreased, (6) some students learn to “loaf” because the learning community progresses with or without their contributions, (7) some students may become convinced they are helpless to understand complex conceptual understandings without the support of the group and become overly dependent and develop low self esteem and self efficacy, (8) higher volumes of information generated during community processes can create a condition of information overload for individual students, and (9) fear of negative evaluation can cause students to withdraw and avoid participating in dialogue and negotiation with other students.

Lack of exposure. A major problem for collaborative learning lies not in its pedagogical methods or instructional design implications, but in nontraditional students’ lack of exposure to it. Collaborative learning was unlikely the predominant pedagogical approach when most nontraditional students attended primary, secondary and postsecondary school. According to Nelson-LeGall (1992):

Relatively few [students] attend schools that regularly encourage peer interactions as a major means of learning. Moreover, with increasing grade level in school, [students] are likely to encounter classroom-learning situations in which competition and independent performance are increasingly normative (Eccles et al., 1984). It is likely, therefore, than unless [students] begin elementary school in classrooms that emphasize the social sharing of cognitive learning activities, [students] will come to [collaborative] learning groups with perceptions that collaborating with and assisting peers in classroom learning activities are not "normal" behaviors for [students] (p. 60).
Groupthink. Without careful planning and monitoring by the teacher and students, collaborative interactions can hinder learning and reduce rather than improve social relations necessary for online learning communities. For example, pressure in a group for conformity (i.e., “groupthink”) can limit the willingness of students to contribute their ideas for fear of being dominated or shunned by their peers. When a group of students trusts one another and are motivated to produce socially constructed knowledge, they will often support one another’s conceptual understandings even through those understandings may contain misconceptions or critical gaps in understanding. Once momentum builds for group consensus, it may be difficult to convince students to change their newly adopted conceptual framework.

A sub-problem is stronger personalities in a learning community may promote their perception of a concept, which may overpower others in the community who may have a better understanding of the concept. This results in problematic understandings based on social pressure rather than meaningful, iterative learning and group collaboration (Noelle-Neumann, 1984, 1991). Low achievement students are especially vulnerable to this threat. These students may be ignored or even ridiculed while the contributions of high achievers are accepted and reinforced, regardless of the merit of their ideas (Anderson, Holland & Palinsar, 1997; Cohen, 1986).
Contrary to the goal of social construction of knowledge, existing misconceptions might be reinforced or the worst, not the best, conceptions may be combined to construct less than accurate conceptual understandings.

**Gender.** Some research indicates a student’s gender mediates their activities in collaborative learning communities. When there are just a few girls in a learning community, they tend to be left out of the dialogue and negotiation unless they are the most competent or assertive students in the learning community. However, when there are only a few boys in a learning community, they tend to dominate and be “interviewed” by the girls unless these boys are less able than the girls or are very shy (O’Donnell & O’Kelly, 1994; Webb, 1985; Webb & Palincsar, 1996). Although the research findings seem to apply only to K-12 educational environments, online learning in postsecondary education should monitor nontraditional students to make sure all students, regardless of gender, are participating in collaborative community activities and learning. Duplicate studies on adult, online nontraditional students are clearly needed.

**What makes Collaborative Learning Successful?**

Educators fool themselves if they think directives to "work together," "collaborate," and "be a team," will be enough to create collaborative online learning communities. Placing students in groups and telling them to work together does not, in and of itself, result in collaboration. Designing online learning environments in which students do work collaboratively requires an understanding of the components that make collaboration work. Collaborative skills are necessary
for effective collaborative community functioning and teachers cannot assume students possess these skills. Often these skills, such as giving constructive feedback, reaching consensus, and involving every student in dialogue and meaning negotiation must be taught and practiced before students engage learning tasks collaboratively. The essential components of collaboration are positive interdependence, promotive interaction, individual and group accountability, interpersonal and small group skills, and group processing (Johnson, Johnson & Holubec, 1993). Systematically structuring these basic elements into collaborative online learning environments assists in, but does not guarantee, successful implementation of collaborative learning in learning communities.

Positive interdependence. The first and most important element in structuring collaborative learning is positive interdependence. Positive interdependence is successfully designed when students perceive they are linked with one another in such a way that one cannot succeed unless everyone succeeds. Social interdependence theory (Johnson et al., 1984, 1989) suggested for collaborative learning to be successful, students must perceive their individual goals as similar to or supported by the community’s goals and the goals of other students. That is, for individuals to succeed, the community must succeed which is only possible if students help one another to succeed. As such, the student and the community are interdependent and reciprocally determine the success of the other.
If this interdependence is not felt in the community, students may see their goals as separate and may decide either to ignore the community and other students’ goals and proceed separate from them, or try to compete with other community members to succeed individually.

**Promotive interaction.** Students need to do authentic work together in which they promote one another’s successes by sharing resources, helping, supporting, encouraging and applauding one another’s efforts to achieve. There are important affective activities (e.g., self-worth, self-esteem and self efficacy) and interpersonal dynamics that can only occur when students promote one another’s learning. Johnson, Johnson and Holubec (1993) argued face-to-face interaction was important because so much of learning from other students involved them understanding the state of learning others were in, often at a personal or emotional level. Their finding begs the question: If nontraditional students are not within close physical proximity to their colleagues, how can they learn collaboratively? One answer might be: new online learning spaces. New technologies allow teachers and students to use both synchronous and asynchronous video, audio, multimedia and text to bridge geographical distance. Learning management systems (e.g., WebCT® and Blackboard®) have tools that allow students to publish home pages with their pictures and short biographies to introduce themselves to their peers. Online learning tools also provide students with collaboration tools such as text chat, bulletin boards, group presentation spaces (i.e., web site space), e-mail and electronic white boards.
Although these technological tools do not supplant face-to-face interaction, educators might use these educational technologies to facilitate collaborative online learning.

**Individual and community accountability.** The community should be held accountable for achieving its learning goals and each student should be held accountable for contributing her share of the work. Even though students work together and help each other to reach community learning goals, members of the learning community should also demonstrate their ability to learn on their own. Students are held individually accountable for learning, often through individual assessments. This design requirement does not suggest the ultimate goal of learning is individual comprehension, but rather is a response to extrinsically motivated students who may not “put in their fair share” when working toward the learning community’s goals. While extrinsically motivating these students with individual assessment is not the goal of collaborative learning, it may help to ensure all students (both intrinsically and extrinsically motivated) continue to see their learning goals as interdependent and, as a result, work collaboratively toward the learning community’s learning goals.

**Interpersonal and community / social skills.** Collaborative learning is inherently more complex than competitive or individualistic learning because students have to engage simultaneously in task work (learning academic subject matter) and teamwork (functioning effectively as a community). Social skills for effective collaborative learning do not magically appear when collaborative lessons
are deployed. Instead, social skills must be taught to students as purposefully and precisely as academic skills. Leadership, decision-making, trust-building, communication, and conflict-management skills empower students to manage both teamwork and task work successfully. As collaboration, negotiation and conflict are inherently related, the procedures and skills for managing conflicts constructively are especially important for the long-term success of collaborative online learning communities.

**Community processing.** Community processing exists when community members discuss how well they are achieving their learning goals and maintaining effective working relationships. Learning communities need to describe which community actions are helpful and unhelpful and make decisions about which behaviors to continue or change. Students should monitor community processes and interpersonal relationships to make sure the community is working effectively and to ensure students are actively supporting one another. Students should take time to ask, “How are we doing as a group? Is everyone working together?” Community processing should be iterative and the results of the exercise should be publicly displayed within their learning community. This experience, if done constructively, might create community solidarity and promote social bonding within the learning community.
Moving Toward Conceptual Change

This section explores collaborative learning as a viable pedagogy to socially construct understandings in collaborative online learning communities. Because, in a constructivist framework, learning occurs when students encounter new information, students should be able to position new concepts into their existing conceptual frameworks. While this process can be relatively simple if the new information fits easily into students’ existing conceptual frameworks, conceptual change becomes complex and challenging when new information does not fit, or worse, is dissonant with students’ existing interpretations. Conceptual change theories are concerned with the latter and seek to explain how students restructure existing conceptual frameworks to accommodate new information, under what learning conditions conceptual change is likely to occur, and if the conceptual change is fast or slow, evolutionary or revolutionary and/or temporary or permanent.

Conceptual Change

*In times of massive change, students inherit the world while the learned remain beautifully equipped to deal with a world that no longer exists.*

- Eric Hoffer

What do students do with new information that does not fit comfortably into their existing conceptual framework? What students do with new information is particularly important because one goal of postsecondary education is to teach nontraditional students to be flexible in changing their understandings based on new, credible information. This process is commonly referred to as conceptual
change. This section will explore conceptual change theories and under what conditions students are willing to make conceptual changes to their existing understandings.

This section begins with an examination of cognitive structure to develop the language and the conceptual base on which conceptual change theories are founded. This is followed by discussions of how and why students manipulate their cognitive structures based on new information, students’ approaches to learning and an examination of the major conceptual change theories.

Cognitive Structure

Before teachers can comprehend how students’ make changes to their understandings, they must first appreciate the cognitive structure within which the understandings are housed. What is cognitive structure? Cognitive means “of the mind”; the capacity to understand and think. Structure refers to the form, the arrangement of concepts, and the organization of conceptual hierarchies within a conceptual framework. The emphasis on structure is not the concepts, although they are important, but on the way those concepts are related to one another. So cognitive structure is both the concepts and conceptual relations that allow students to create meaning from new information. The meaning students assign to concepts and the intricate conceptual frameworks students construct and reconstruct which makes them knowledgeable in particular domains are both defined by the complexity and richness of their conceptual relations as they change over time.
Concepts

Concepts are central to cognition because they are units of mental representation (Carey, 1992). Concepts are the idea modules from which propositional thought is created. Concepts can be new information categorized as being of a particular kind by comparing the new information to students’ existing knowledge bases. "Concept" is central to many of the cognitive sciences. In cognitive psychology, conceptual encoding occurs in sensory, short-term and long-term memory. Novak and Gowin (1984) defined “concept” as “a perceived regularity in events or objects, or records of events or objects, designated by a label” (p. 4). In artificial intelligence, concepts are the cases from which expert systems are built to enable computer-based expertise (Kolodner, 1993; Newell & Simon, 1972).

Concepts are perceived patterns labeled with words and employed in thought and communication. As such, students’ experiences are mediated by concepts. The continuous flow of students’ experiences are punctuated by the conceptual structure and subsequent organization of these experiences in students’ conceptual frameworks. Abstract articulations are made possible by students’ ability to symbolize.

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22 While not a cognitive science, behaviorism viewed a concept as the likelihood a student would respond to stimuli (Thorndike, 1932; Hull, 1943; Skinner, 1953).

23 In comparing philosophical vs. psychological concepts, one must distinguish philosophical concepts labeled as abstract thought and independent of events and objects in the world, and psychological concepts understood as modules representing real world objects or events within a cognitive framework of conceptual understanding.
West and Pines (1985) emphasized the importance of this ability to perceive and reciprocally define reality vis-à-vis concept labels and language as students conceptualize their experiences.

Each concrete concept is a human invention, a way of “slicing up” and organizing the world. Once labeled, they become communicable through the use of a language which, in turn, imposes organization on the world. Hence the power of an acquired language to channel human perception and thought; hence Wittgenstein’s (1961) astute proclamation that the limits of his language were the limits of his world. In the mature linguistic adult, thought and language are inextricably intertwined (Vygotsky, 1962) because of the fundamental role that symbols play in the manipulation of concepts in thought and communication. A word is like a conceptual handle, enabling one to hold on to the concept and to manipulate it (p.108).

Conceptual Relations

A concept in isolation is meaningful only to the idea it represents, but is devoid of meaning within a student’s larger conceptual framework. Concepts become meaningful when they are interconnected in a conceptual framework and can be thought of as junctions for multiple conceptual relations. These relations are the hierarchical links and cross-links from which meaning is constructed. Just as concepts cannot exist in isolation, neither can conceptual relations. However, in tandem, they form rich conceptual frameworks.

The conceptual relations links and cross-links are called propositions. Propositions may be communicated in sentence form called prepositional statements. For example, if the concepts “tree” and “branch” are connected with the proposition “part of,” the propositional statement can be read as “branches are part
of a tree.” Creating new knowledge requires the construction of new and restructured conceptual relations and propositional statements. Relations exist both between both objects and events in the world and between the concepts and propositions that signify them. Students use symbols to view, manage and share their understandings. West and Pines (1985) emphasized the importance of analyzing changes in conceptual relations:

All meaning is relational! If this is true, …then it follows that the elucidation of meaning is only possible through the analysis of relations. Complexity, in the real world and of meanings, is a result not of the quantity of relations among [concepts], but of a combination of both quantity and quality of relations, that is, the number and types of relations that exist (p. 102).

While quantity of concepts and the relations connecting them are an initial indicator of understanding and are useful at tracking students’ conceptual change processes, quantity of concepts in one’s conceptual framework does not necessarily equate to complexity of understanding. Complexity arises out of multiple concepts and conceptual relations related in novel ways (e.g., cross-links indicating relations among seemingly disparate concepts).

Mental Models

A mental model is a conceptual structure for understanding how students encode, store, utilize and change their conceptual frameworks as they learn. Mental models are representations of reality students use to understand specific phenomena.

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24 This networked metaphor of conceptual relations is the primary foundational theory this dissertation will build upon as it discusses using concept maps to visualize students’ conceptual change processes.
Norman (1988) described them as: "the models people have of themselves, others, the environment, and the things with which they interact" (p.17). Mental models provide predictive and explanatory power for understanding these interactions and are consistent with theories that postulate internal representations of thinking processes (e.g., Newell & Simon’s General Problem Solver, 1972). Johnson-Laird (1983) argued mental models are the basic structure of cognition: "It is now plausible to suppose mental models play a central and unifying role in representing objects, states of affairs, sequences of events, the way the world is, and the social and psychological actions of daily life" (p. 397). Schank and Cleary (1995) argued expectations created by students’ existing schema act as a conceptual filter through which mental models are constructed and changed. Learning new concepts and conceptual relations requires students to compare new information against their existing mental models. If the new information does not fit into students’ existing mental models, students or the learning community can either change their mental models or handle the new information in a new way.

Schumacher and Czerwinski (1992), however, pointed out the shortcomings of mental models. They suggested mental models are incomplete and constantly evolving and are not always accurate representations of a phenomenon as they typically contain errors and contradictions. Mental models are parsimonious and provide simplified explanations of complex phenomena and often contain measures of uncertainty about their validity that allow them to used even if incorrect.
Schema theory. While there are multiple types of mental models, this report focuses on Bartlett’s (1932, 1958) concept\textsuperscript{25} of schema\textsuperscript{26}. Bartlett suggested long-term memory took the form of schema, which provided a conceptual framework for making sense of existing conceptual understandings and fitting new information into existing schema. Schema theory assumes students’ minds are neither blank nor ever completely formed (Johnston, 2001). Schematic networks consist of concepts, conceptual relations, the propositional statements defining the relationship and the superordinate hierarchy within which understanding is located. Concepts, from a schematic approach, then, only contain meaning in relation to other concepts. Further, students access concepts in their schema in relation to how those concepts fits into their conceptual framework. Bartlett (1932, 1958) suggested students’ conceptual frameworks guide how they make meaning out of new information. The more complex a student’s schema, the more likely she will be able to use her existing knowledge base to assimilate and/or accommodate new information.

The meaning and organization of new information in students’ existing schema is the main goal of conceptual change and, more to the point, learning. Schema theory presented students’ minds as composed of networks of interrelated

\textsuperscript{25} The concept was derived from studies of memory in which students recalled details of stories that were not actually there.
\textsuperscript{26} Although Bartlett first proposed “schema,” cognitive psychologists had further attempted to explain students’ conceptual frameworks as memory representations in the form of scripts, frames or schema (Anderson & Pearson, 1984; Bartlett, 1958; Spiro, 1980). “In order to deal with the fact that much of our knowledge seems integrated, psychologists have developed the idea of schema” (Gagne, Yerksovich and Yerkovich, 1993, p.81). Spiro (1980) demonstrated the constructive and complex nature of schema and highlighted conceptual ecology concepts that influenced how students create their schematic conceptual frameworks.
concepts and this network may be built both by the individual students and through collaborative interaction with one’s online learning community.

**Manipulating Cognitive Structure**

*If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the student already knows. Ascertain this and teach ... accordingly.*

- David Ausubel

Understanding how concepts and conceptual relations are situated in the mind is useful, but teachers also need to know how to manipulate students’ existing conceptual understandings with new information. The following four theories describe how and under what conditions students’ conceptual frameworks change.

**Assimilation Theory**

Ausubel’s (1963) assimilation theory, as explained in *Psychology of Meaningful Verbal Learning*, argued learning new information by integrating it into a student’s existing conceptual framework is a function of both the quantity and the quality of the student’s cognitive structure. Ausubel’s theory extends from symbolic information processing theory where learning is a combination of the knowledge stored in the student’s long-term memory and the student’s information processing capabilities.
Ausubel (1978) suggested researchers look deeper into the makeup of a student’s cognitive structure to understand conceptual change processes.

Concept assimilation is learning new conceptual meanings by being presented with the criterial attributes of concepts and by relating these attributes to relevant established ideas in the cognitive structure [and] is typically characterized by an active process of relation to, differentiation from and integration with existing relevant concepts. The more active this process is, the more meaningful and useful assimilated concepts are (p. 98).

**Subsumption.** In the course of conceptual change, new information is linked with existing concepts and conceptual relations in a student’s conceptual structure. Ausubel (1968) suggested this linkage occurs when specific, less inclusive concepts are linked to more general, existing concepts in a student’s conceptual framework. Ausubel emphasized this linking process by labeling general, existing concepts as “subsuming concepts” or “subsumel.”

The role of a subsuming concept is an interactive one, providing an anchor for linking new information to existing interpretations. Furthermore, the subsuming concept and the new information interact, modify and reciprocally define the other. That is, in the process of adding quantity (new concepts) to a student’s existing conceptual framework, both the quantity and quality of the conceptual framework is altered. There are more concepts in the conceptual framework, and, as such, there are new opportunities for linking and cross-linking concepts, conceptual relations and propositional statements therein. To use Ausubel’s terminology, subsumed information results in increased differentiation of subsumers, thus adding to the
student’s capacity for easier subsequent subsumption of new information. For example, adding new information to students’ conceptual frameworks is like adding web sites to the Internet. With each new web site, there is both an opportunity to learn the information on the site (quantity) and link the new site within other sites in ways that allow the linker to understand what they think they understand in new ways (quality). It is this interactive process between new information and existing knowledge that forms the core of Ausubel’s (1963) assimilation theory of learning.

**Progressive differentiation.** Ausubel (1963) argued much of learning is gradual and assimilative in nature. Assimilative learning occurs when students encounter new information and subsume it into their existing conceptual frameworks without making any radical changes to their existing framework. As such, assimilation results in a weak form of conceptual framework restructuring, and an incremental change in conceptual understandings. In contrast, there exist less common, revolutionary learning moments when students must make structural changes to their existing cognitive frameworks to accommodate new information. Accommodation signals a significant and rapid shift in one’s understandings based on this strong conceptual framework restructuring.

As learning proceeds, development and differentiation of subsuming concepts within students’ conceptual frameworks occurs. The process of refining one’s conceptual framework by adding concepts, restructuring existing conceptual relations to assimilate and/or accommodate new information, and/or restructuring one’s conceptual framework simply to make better sense of one’s overall knowledge
base is called progressive differentiation. In Ausubel’s (1968) view, conceptual change works best when general, more inclusive concepts are introduced first and then these concepts are progressively differentiated in terms of detail and specificity

Integrative reconciliation. Subsumption and progressive differentiation lead to more than quantitative addition of new information into students’ conceptual frameworks. Qualitative changes also occur when students’ conceptual frameworks are modified to accommodate new concepts and new conceptual relations. As students subsume concepts into their conceptual framework hierarchy, the meanings of all existing concepts are modified, at least slightly, because there are newly created conceptual relations across the conceptual structure. Students seeking to reconcile newly integrated concepts must substantively incorporate these new concepts into their existing conceptual frameworks. It may be necessary to alter existing conceptual structure to accommodate and make sense of the new concepts in relation to existing conceptual understandings. These new relationships between new concepts and existing conceptual structure can be represented as relational cross-links. These cross-links represent what Ausubel, Novak and Hanesian (1978) described as integrative reconciliation.

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27 This idea is linked to and explored further in Bruner’s (1966) scaffolding theory and Reigeluth’s (1992) elaboration theory.

28 Neurologically, at least some new synapses form between the neurons storing the new concept and neurons storing all previously learned, related concepts (Novak, 1998).
While there are some obvious similarities between Ausubel’s (1968) subsumption, progressive differentiation and integrative reconciliation and Piaget’s (1969) assimilation, accommodation and equilibration, there is an important difference (Novak, 1998). Piaget’s cognitive developmental stages referred to general reasoning capacity, whereas Ausubel’s (1963) assimilation theory positioned cognitive ability as primarily a function of the richness of the relevant conceptual framework a student has in a specific knowledge domain.

**Lateral Thinking Theory**

DeBono (1967) suggested students should systematically reconceptualize existing and newly formed conceptual frameworks. According to Gestalt psychology, restructuring, or conceiving of a learning problem in a new or different way may lead to sudden insight. Furthermore, after struggling with a learning problem, it may be helpful to set it aside for a time to enable an unconscious restructuring of the problem (Gleitman, 1991). This cognitive break interrupts the previous fixed way of thinking about the problem so the student can restructure her understanding of the problem and return to the problem with new perspective and new ideas of how to restructure her existing conceptual framework to accommodate newly subsumed information. The point of lateral thinking is many complex learning problems require a non-conventional approach to solve them successfully.
**Cognitive Flexibility Theory**

An extension of DeBono’s (1967) lateral thinking theory, Spiro and Jehng’s (1990) cognitive flexibility theory suggested students look at the conceptual structure of a learning problem in various ways, sometimes randomly, to understand how it fits into their existing conceptual frameworks. Spiro and Jehng argued transfer of one’s understandings to new learning scenarios required working with multiple conceptual representations enabled through the use of multiple, flexible views of one’s conceptual network. “It is only through the use of multiple schemata, concepts, and thematic perspectives that the multi-faceted nature of the content area can be represented and appreciated” (Jacobson, 1990, p. 21). Cognitive flexibility theory borrowed the rich metaphor of criss-crossing the landscape from Wittgenstein (1953) for physically describing this process. The student criss-crosses the conceptual landscape of the domain by viewing it from multiple, flexible perspectives.

Spiro and Jehng (1990) further suggested learning in complex, ill-structured learning environments was better supported if students had the capacity to explore their ideas in flexible, non-fixed ways using educational tools that enabled such risk

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29 Principles extending from cognitive flexibility theory include: (1) learning activities should provide multiple representations of new information; (2) learning materials should avoid oversimplifying the content domain and support conceptual ecological information; (3) learning materials should be multiple and varied case-based examples that represent the ill-structured, complex reality of concepts in the real world (Spiro & Jehng, 1990); (3) in order to construct useful conceptual frameworks, students should compare and contrast the similarities and differences between cases and emphasize conceptual understanding construction; (4) information sources should be highly interconnected rather than compartmentalized; and (5) educational tools provided to students should enable explicit visualization of conceptual understandings while providing multiple opportunities and methods to flexibly view and change one’s conceptual framework (Green, 2000).
without substantial perceived loss to one’s constructive investment. Spiro and Jehng (1990, p. 165) stated: "By cognitive flexibility, we mean the ability to spontaneously restructure one's knowledge, in many ways, in adaptive response to radically changing situational demands.” Cognitive flexibility, then, is a function of both the way conceptual frameworks are represented and the flexible conceptual change processes that operate on those conceptual frameworks.

**Scaffolding Theory**

One of the most important parts of the learning process is what students bring to the learning situation in terms of existing conceptual understandings. What students already know determines to a great extent what they will pay attention to, perceive, learn, remember, and forget (Greeno, Collins & Resnick, 1996; Shuell, 1986). Alexander (1992) argued that what students already know is a scaffold that supported the construction of their future knowledge. A scaffold (Bruner, 1960) is any support or process that helps a student solve a learning problem or achieve a learning goal, which would otherwise be beyond her unassisted efforts. Scaffolds may also help students to notice gaps and misconceptions in their understandings, engage students in creating an inventory of what they think they understand and question it, and involve students in structuring and restructuring new information in their conceptual frameworks.
Bruner\textsuperscript{30}, in *The Process of Education* (1960), argued curriculum should be scaffolded so students could more easily incorporate new information into their existing conceptual frameworks:

> The curriculum of a subject should be determined by the most fundamental understanding that can be achieved of the underlying principles that give structure to a subject. Teaching specific topics or skills without making clear their context in the broader fundamental structure of a field of knowledge is uneconomical. An understanding of fundamental principles and ideas appears to be the main road to adequate transfer of training. To understand something as a specific instance of a more general case, which is what understanding a more fundamental structure means, is to have learned not only a specific thing but also a model for understanding other things like it that one may encounter (pps. 6, 25, 31).

Bruner (1960) argued the role of the teacher was to build scaffolds to provide students with a structure within which they could construct new interpretations. One goal of scaffolding was to help the student reach self-actualization and higher levels of self efficacy by creating learning scaffolds that keep the student at the leading edge of her zone of proximal development (Vygotsky, 1978).

\textsuperscript{30} Bruner (1966) later argued a theory of education should address four major aspects: (1) the experiences and educational environments that enable the student to learn (readiness), (2) the methods by which new information can be structured so it can be most readily grasped by students (spiral organization), (3) the most effective sequences in which to present material (scaffolds), and (4) instruction should be designed to facilitate extrapolation and fill in gaps in understanding by “going beyond the information given.” Bruner (1966) suggested methods for structuring conceptual understandings should result in students’ simplifying, generating new conceptual relations, and increasing the manipulation of new information.
In order to keep the student at the leading edge of her zone, the teacher scaffolds new concepts just in front of the student’s current comprehension to provide a skeleton conceptual framework on which the student could “hang” new concepts and conceptual relations. Bruner (1966) termed this process “guided discovery.”

Woolfolk (2001) suggested scaffolded learning was useful because it allowed the student to select and transform information, construct hypotheses and make decisions based on a “known” cognitive structure. Scaffolded conceptual frameworks provided meaning and organization to students’ experiences and empowered them to go beyond the information given. This reconceptualization of conceptual understandings through new conceptual structures prompted students to think about conceptual relations in new ways.

Scaffolding, however, may not be useful for nontraditional students unless the scaffold leads them to discover authentic understandings they can use in their professional workplace. Scaffolding also requires a commitment by the teacher to both monitor students’ conceptual changes and adjust individual scaffolds to keep students at the leading edge of their respective zones of proximal development. Should the teacher fail in this update process, the scaffolds may become stale and useless to the student.
What will Students do with New Information?

Students will encounter new information that does not easily fit into their existing conceptual frameworks their entire lives, and their success in their workplace will largely be defined by their ability to assimilate and/or adjust their conceptual frameworks to incorporate and make meaning from the new information. Chinn and Brewer (1993) argued this issue was critical for two reasons:

The first is that encountering contradictory information is a very common occurrence when one is learning (Carey, 1985). Second, [students] typically resist giving up their pre-instructional beliefs. Instead of abandoning or modifying their pre-instructional beliefs in the face of new, conflicting data and ideas, [students] often staunchly maintain the old ideas and reject or distort the new ideas (p.1).

Assimilation

Lakatos (1970) distinguished between two types of propositions within students’ conceptual frameworks. *Hard core* propositions cannot be altered without rebuilding the large sections of conceptual framework, but *protective belt* propositions can be altered while preserving the key meaning in the existing conceptual framework. Thus, one response to new information is for the student to make relatively minor modifications to her conceptual framework. A student who responds in this way accepts the new information but is unwilling to completely give up her conceptual framework to accommodate the new information in its entirety. Ausubel (1963) and Piaget and Inhelder (1969) called this process assimilation.
Accommodation

The strongest effect new information can have on a student’s conceptual framework is to compel the student to radically restructure\textsuperscript{31} that framework and the concepts and conceptual relations therein. In this response, the student accepts the new information by restructuring her conceptual framework to accommodate the new information. While this dissertation focuses primarily on assimilation and accommodation among students’ multiple conceptual change processes, Chinn and Brewer (1993) suggested there are seven basic responses a student can assume when entertaining new information including: ignore the data, reject the data, exclude the data from the domain of theory A, hold the data in abeyance, reinterpret the data while retaining theory A, reinterpret the data and make peripheral changes to theory A, or accept the data and change theory A, possible to theory B. There are implications for students’ conceptual structures for each of these responses to new information that affect students’ ability to effectively assimilate and/or accommodate new information into their existing conceptual frameworks.

Chinn and Brewer (1993) proposed three factors that interact to determine how students respond to new information: students’ prior knowledge, if students believe the new information is credible, and the processing strategies students use as they engage the new information.

\textsuperscript{31}The history of science suggests radical conceptual restructuring often requires a series of empirical anomalies, which collectively appear to be better explained by an alternate conceptual structure (Kuhn, 1962; Thagard, 1992).
Prior knowledge. There are four factors of prior knowledge that mediate how students respond to new information. First, the entrenchment of the student’s prior knowledge (Posner et al., 1982; Vosniadou & Brewer, 1992) requires the new information fit neatly into one’s existing conceptual framework. Theories with substantial evidentiary support and used in multiple explanations across one’s conceptual framework are deeply entrenched. Second, the student’s ontological commitments or their beliefs about the fundamental categories and properties of the world (Chi, 1992) act as a lens through which new information are filtered. Third, the student’s epistemological commitments or beliefs about what knowledge is and what qualifies as a credible data (Posner et al., 1982; Toulmin, 1972) also acts as a filter before new information is entertained. Fourth, the more complex one’s prior knowledge, the more difficult it is to change that knowledge.

Students’ prior knowledge is a critical factor in understanding how students will respond to new information. Students will recognize and work with new information if they can access related prior knowledge in their existing knowledge bases. The interesting consequence of prior knowledge affecting new information processing is: if students do not have the prerequisite prior knowledge when encountering new information, they may not even know it is new (Longino, 1990). Lord et al. (1979) found students were more willing to change their existing theories based on new information before they discovered theories that could reject the data.
The dilemma, then, for teachers attempting to design learning scaffolds to push students to the edge of their zones of proximal development, is teachers may be promoting cognitive dissonance with new information students do now know is new because they do not have the prior knowledge necessary to recognize the new information as dissonant with their existing cognitions.

**Credibility.** For students to entertain new information, the data must be perceived as credible. Students will reject data not seen as credible. As conceptual change is not possible unless the student is willing to entertain new information and new conceptual relations, it is important teachers find methods to present new information as being credible. First, Reinard (1988) suggested credible communicators produce more credibility when the communicator is perceived by the student to be an unbiased expert. Second, show students the data were generated vis-à-vis accepted methods of data collection and analysis (Mahoney, 1976). Third, credibility can be shown through replication of study results. Fourth, allow students to directly observe the experimental results of the replicated studies (Chinn & Brewer, 1993). Fifth, data students already accept is credible by definition.

**Processing strategies.** Once a student has decided to engage new information, there are a number of ways they can process it. According to Craik and Lockhart’s (1972) levels of processing theory, new information is processed at multiple levels simultaneously\(^{32}\) depending on the form of the information. Processing information

\(^{32}\) For example, Paivio’s (1986) dual coding theory argued that visual images in conjunction with verbal information will be processed at a deeper level than either information channel independent of the other.
deeply includes: attending carefully to the new information, striving to understand
the new information, and exploring the connections between the new information
and one’s existing conceptual framework (Nickerson, 1991). Moreover, Cooper and
Croyle (1984) suggested conceptual change is more likely when students process
new information deeply.

Unfortunately, students often fail to process new information deeply. Rather,
students often attend to new information that supports their existing theories
(Galotti, 1989). However, Tetlock (1983) found if students anticipated they had to
justify their reasoning, they processed new information more deeply and were
therefore more likely to change their existing conceptual frameworks to
accommodate the data. This finding suggested collaborative learning and public
displays of understanding in online learning communities may facilitate deep
processing strategies and subsequently, deeper conceptual change among
nontraditional students. Without this personal commitment to process new
information deeply, students may process it superficially, and meaningful
conceptual change is less likely to occur. These findings suggest understanding
nontraditional students’ approaches to learning may be helpful in constructing
learning environments that promote conceptual change.
Approaches to Learning

Knowing under what conditions students may make changes to their existing conceptual understandings is useful, but not sufficient. Teachers must also understand students’ approaches to learning, their rationale for learning, to construct collaborative learning environments.

Educational research on approaches to learning has moved away from an assumption of stable student personality characteristics and rather emphasized the choices students make in selecting an approach to a particular learning moment (Duff, 1997). In their seminal study on conceptions of and approaches to learning, Marton and Säljö (1976) reported a difference in how students went about reading an academic article. Students who read the article with a “deep” approach looked for meaning in the article and related it to their existing conceptual frameworks. Students who utilized a “surface” approach relied on rote learning and memorization in isolation to other ideas when processing the same article.

Deep vs. Surface Approaches to Learning

The deep approach\textsuperscript{33} to learning implied genuine engagement with the learning task. The intention to relate new information and existing knowledge brought into play important intellectual processes, such as relating and organizing ideas (Pask, 1976, 1988), and subjecting evidence to detailed logical analysis, both

\textsuperscript{33}Novak (1998) argued deep learning had three key advantages over surface learning: (1) information processed deeply was retained longer; (2) subsumed information resulted in increased differentiation of subsumers, thus adding to the capacity for easier subsequent learning of new information; and most important (3) information processed deeply could be applied to a wide scope of new learning scenarios; that is, high transferability of deeply subsumed conceptual understandings.
of which were necessary to achieve deep levels of learning (Entwistle, McCune & Walker, 2000). Learning deeply is a constructive dialogic process by which students make meaning of new information by reconciling it with their existing conceptual understandings and the ideas of their online learning community. A deep approach is likely to result from intrinsically motivated, self-regulated students who sees their learning goals as interdependent with the learning community. A deep approach is also likely to result from learning environments in which the teacher shows interest in students’ learning (Ramsden, 1979) and where students have an opportunity to direct and construct their own learning (Ramsden & Entwistle, 1981). Students in such a learning environment are also more likely to use a deep approach to process new information (Pintrich & Schrauben, 1992).

In the surface approach, students focused on learning tasks, unrelated bits of information that were most efficiently learned by rote memorization (Entwistle, 2000). Students who processed new information with a surface approach view learning as what needs to be learned for the test and do not understand or see the need to link the new information into their conceptual frameworks. A surface approach is likely to result from students who are extrinsically motivated and see their learning goals as in competition with their peers (Entwistle & Tait, 1990), assessment methods which reward reproducing information (Dart and Clarke, 1991), and anxiety (Fransson, 1977) which can be exacerbated by a heavy workload (Ramsden & Entwistle, 1981). The surface approach may be regarded as transmissional as it emphasizes memorization of new information.
Deep vs. surface recall of information. The differences in recall of information after deep vs. surface learning were also important. Suppes and Ginsberg (1963) argued information learned by surface methods inhibited subsequent learning of additional similar information. Even information learned by surface methods that was forgotten inhibited learning of similar new information. The reverse effect, however, operated after deep learning. The psychological savings in surface learning were only for the relearning of precisely the same information, whereas deep learning resulted in savings for relearning and facilitation of learning new, similar information (Novak, 1998).

Students who engaged in deep learning encoded complex conceptual frameworks rather than unconnected, isolated concepts that characterized surface students. The principle benefits of deep learning were better encoding and retrieval of new information, facilitation of future learning due to rich conceptual frameworks, and the ability to use existing knowledge to solve new learning problems (Ausubel, Novak & Hanesian, 1978).

Strategic vs. Surface Approaches to Learning

In addition to deep and surface approaches to learning, Entwistle (2000) suggested the need for an additional category to explain students’ approaches to learning new information. Strategic students were acutely aware of the assessment process and attempted to achieve high assessment marks by: organizing their study habits, managing their time (Entwistle & Ramsden, 1983) and monitoring their

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34 Strategic students display metacognitive alertness and self-regulation (Vermunt, 1998; Pintrich & Garcia, 1994).
study effectiveness (Entwistle, McCune & Walker, 2000). Entwistle’s (2000) interviews with students suggested strategic students have two distinct foci of concern, the new academic information and the rules of the assessment system. Interest in the academic content is typical of a deep approach, but concern of assessment measures is distinctly strategic. Whereas the distinction between deep vs. surface approaches to learning was derived from analyses focused on extracting meaning from an article, the strategic approach vs. surface approach (Tait & Entwistle, 1996) attempted to predict how students act in study situations.

Learning Approach Combinations

Inventories measuring deep vs. surface approaches to learning and strategic vs. surface approaches to learning have found the deep / strategic combination is most likely to lead to academic success and more complex conceptual understandings (Biggs, 1987; Meyer, Parsons & Dunne, 1990). However, when rote memorization and not deep understanding is the goal, a surface / strategic combination may well prove more adaptive (Entwistle, 2000). Students with the least academic success generally utilize a surface combination (Tait, Entwistle & McCune, 1998) or display dissonant conception / study combinations (e.g., combining deep approaches of learning with surface approaches to learning) (Meyer, 1991; Entwistle, Tait & McCune, 2000).
Typing Non-Traditional Students

Further, understanding students’ approaches to learning is an important step in typing nontraditional students. As the percentage of nontraditional students in postsecondary education continues to rise, the typical student learner type profile is changing (Schroeder, 1996). Traditionally, learning type models classified students according to how they received and processed new information. These information acquiring and processing types have been operationalized in a number of models including Kolb’s Learning Style Inventory (1984), the Myers-Briggs Type Indicator (MBTI) (1962), and Gardner’s Theory of Multiple Intelligences (1991). Because different learner types preferentially access and process information in different ways, educators need to understand nontraditional learner types to successfully design online learning environments. Understanding nontraditional students approaches to learning may be helpful to this process.

While traditional learner type measures and understanding the needs of nontraditional students inform educators’ understandings of nontraditional learner types, teachers might also consider students’ self efficacy and experience with using computers and their approaches to learning to determine what apriori experiences nontraditional students bring with them to their learning environment. As online learning requires the use of numerous educational technologies, these two constructs may be important in nontraditional students accessing, processing, and sharing their understandings.
Armed with an understanding of how students’ cognitive frameworks are structured, how students make changes to their knowledge bases based on what they do with new information and their approaches to learning, multiple theories of conceptual change have been proposed.

**Conceptual Change Theories**

According to Greek legend, the selection of Gordius as king of Phrygia was the fulfillment of a prediction made by an oracle. The oracle predicted the next king would drive his wagon into the public square. Gordius not only drove his wagon in at just the time a new king was sought, he also tied his wagon in the temple of the oracle’s god. The knot Gordius tied was so complex and intricate; no one was able to untie it, though many tried. Legend has it the one who could untie the very complex "Gordian Knot" would rule Asia. One day, Alexander the Great rode into town and encountered the challenge of the Gordian Knot. He, too, attempted to untie the knot and failed. With further contemplation, he proceeded to remove his sword and slash through the knot with one swift stroke—severing the connection and solving the complex problem with a simple solution.

If learning were only so easy. Unfortunately, there is no magic sword students may wield to easily entertain, critique and accommodate new information into their existing conceptual understandings. Rather, conceptual change is a difficult and complex set of learning processes mediated by multiple cognitive, social and environmental factors.

Conceptual change theorists are interested in concepts, how students construct meaning with concepts and conceptual relations, and how these conceptual frameworks change with learning over time. While cognitivists traditionally focus on describing the networked structure of students’ conceptual understandings and
not on change and growth in conceptual relations (Rumelhart, 1980; Spiro, 1980), researchers now use the term “conceptual change” to mean both the process and the outcome of changes in schematic networks. In either case, the change is located in students’ conceptual frameworks. Conceptual change has been a central concern in cognitive research in that cognitivists view learning as synonymous with change. Symbolic information processing theories led researchers to explain change in conceptual understandings through the acquisition of new information and changes in conceptual frameworks (Rumelhart & Norman, 1978). In short, conceptual change deals with students’ existing knowledge and how, why, and under what circumstances these understandings change.

While conceptual change has been researched widely in cognitive science (Carey, 1985; Posner & Strike, 1992; Chi, 1992; Vosniadou, 1994), philosophy of science (Kuhn, 1970, 1977), cognitive development (Piaget, 1930; Vygotsky, 1934) and artificial intelligence (Ram, Nersessian & Keil 1997), no one definition of conceptual change prevails. Conceptual change can be viewed along a continuum from the addition of new information to complete restructuring of hierarchies and branches within conceptual frameworks. Common to all explanations of conceptual change, however, is the idea that either conceptual structure itself, or the way that structure is used, changes over time when the student encounters new information.
Conceptual Change Terminology

A review of the conceptual change literature reveals a range of terminology describing similar aspects of conceptual change processes. Terms such as assimilation and accommodation (Posner et al., 1982; Strike & Posner, 1992; Piaget & Inhelder, 1969), weak and strong restructuring (Carey, 1985), branch jumping and tree switching (Thagard, 1991), conceptual capture and conceptual exchange (Hewson & Hewson, 1992), differentiation and reconceptualization (Dykstra, 1992), and enrichment and revision (Vosniadou, 1994) emerged from the conceptual change literature. Chi (1992) reserved conceptual change for only the most extreme form, ontological categorical restructuring. Alexander (1992) argued cognitive abilities are domain-specific and that labeling processes as conceptual change should be limited to the domain in question. While multiple terms are used to describe conceptual change processes, the most obvious thread running through various literatures was there are large conceptual changes and small conceptual changes.

The most basic changes that occur in students’ conceptual understandings involve small changes or the simple addition of new information. Small changes were described as information addition without cognitive restructuring (Carey, 1985), enrichment vis-à-vis accretion (Vosniadou, 1994), assimilation (Ausubel, 1963; Piaget & Inhelder, 1969; Strike and Posner, 1982), and belief revision (Thagard, 1991). On the other hand, there are large changes that require radical structural changes to students’ existing conceptual frameworks. Large conceptual
changes were described as information addition that required cognitive restructuring (Carey, 1985), revision (Vosniadou, 1994), accommodation (Piaget & Inhelder, 1969; Strike and Posner, 1982), and more than basic belief revision (Thagard, 1992).

**Conceptual Change Model**

Strike and Posner’s (1982) article, *Accommodation of a Scientific Conception: Toward a Theory of Conceptual Change*, put conceptual change on the educational research map. In their article, they established a theory that attempted to explain how students’ “central, organizing concepts change from one set of concepts to another set, incompatible with the first” (p. 211). Their model of conceptual change was founded on two theoretical foundations: the history and sociology of science (Kuhn, 1970) and developmental psychology (Piaget & Inhelder, 1969; Piaget, 1977). Strike and Posner (1982) argued Kuhn’s descriptions of the workings of science and how scientific revolutions evolve were related to Piaget’s descriptions of assimilation and accommodation. First, Kuhn (1970) discussed doing normal science as accretion of knowledge within a scientific paradigm that was strikingly similar to Piaget and Inhelder’s (1969) assimilation theory. Both theories describe how students and/or theorists add new information to what they know without making major changes to their existing conceptual frameworks.
Second, scientific processes that produce new paradigms are analogous to the accommodation of new information whereby students are required to make revolutionary changes to their existing conceptual frameworks to accommodate the new information and the resulting conceptual restructuring.

Central to Strike and Posner’s conceptual change model is the notion that learning is a rational process, a point the researchers would later revise. The student, like the scientist, may rationally evaluate new information and rationally assess whether or not to accommodate it into her conceptual framework (Johnston, 2001). Strike and Posner argued this rational restructuring of one’s conceptual framework was most likely to occur when the following conditions were satisfied: (1) the student must be dissatisfied with her current conceptual understandings, (2) the new information must be intelligible to the student, (3) the new information must appear initially plausible to the student, and (4) the new information should be perceived by the student as potentially useful.

Although the conceptual change model acknowledges the importance of prior knowledge, it presupposed that new information would replace existing ideas. More contemporary conceptual change research, however, argued understandings created from authentic experiences are more resistant to conceptual change (Driver, 1989). Demastes (1996) suggested change is not necessarily an incremental process. And Strike and Posner (1985) reported students may assimilate new information that contradicts their existing interpretations without radically changing their conceptual frameworks.
The conceptual change model has been popular in education research because it allowed researchers and teachers to view students not only as constructors of knowledge, but as jurors who must be convinced that changing their understandings was worth the necessary work (Johnston, 2001). However, as a lawyer possesses only limited information about the jury, conceptual change research has provided the teacher with a better understanding of how, why and under what conditions students change their existing conceptual frameworks.

**Revised conceptual change model.** Pintrich, Marx and Boyle (1993) critiqued Strike and Posner’s (1982) conceptual change model on the grounds it ignored the social, collaborative, contextual and affective influences on conceptual change such as students’ motivations, goals, expectations and needs.

The theoretical difficulties of a cold or overly rational model of conceptual change that focuses only on [students’] cognition without considering the ways in which [students’] motivational beliefs about themselves as students and the roles of [students] in a...learning community can facilitate or hinder conceptual change (p. 167).

Additional research has suggested students’ attention, effort and willingness to persist at a task are influenced by their personal interest in the new information (Hidi, 1990). Further, Pintrich (1989) argued students who found new information important and useful used deeper processing strategies such as elaboration and metacognitive control strategies. Ten years after the publication of the conceptual change model, Strike and Posner (1992) acknowledged the importance of affective and social factors in understanding conceptual change processes. In their revision,
they attempted to explain students’ conceptual ecology by exploring students’ conceptual understandings, misconceptions and gaps in their understanding and suggested these gaps be “seen as dynamic and in constant interaction and development” (p. 160) with cognitive, social and environmental variables.

The phrase “conceptual ecology” was a fitting description for learning environments surrounding conceptual change processes because ecology is the study of organisms and their interactions over time with their environment (von Glasersfeld, 1995). While ecologists study how organisms develop within certain communities, educators examine how, and under what conditions, students change their perceptions vis-à-vis conceptual change processes. This concept is also similar to Bandura’s (1986) reciprocal determinism in which students’ individual attitudes and understandings, the learning community, and community’s behavioral practices all influence and are determined by the other.

**New Method for Sharing Understandings and Conceptual Changes**

This section explored the theoretical foundations for modern conceptual change theories. Comprehending how nontraditional students’ conceptual frameworks are structured, how they change their understandings when presented with new information, and why their approaches to learning are important to the learning process are all critical factors in designing an online learning environment to facilitate social construction of understandings vis-à-vis collaborative learning.
In addition to understanding students’ conceptual change, this study was also interested in facilitating new methods by which nontraditional students could visualize, manage and share their existing understandings and monitor their ongoing conceptual change processes. The next section explores information visualization as a potential solution to this problem.

Visualization of Conceptual Understandings

This section investigates how visualizations of conceptual understandings vis-à-vis concept mapping may empower nontraditional students to visualize their existing understandings, monitor their conceptual changes, and share their understandings with other students and teachers. The section begins with a discussion of information visualization theories. Second, graphic organizers are examined as visual representations of students’ conceptual understandings. The section concludes with an examination of concept mapping as a new educational technology tool and method for nontraditional online learning environments.

Information Visualization

_A graphic is not drawn once and for all; it is constructed and reconstructed until it reveals all the relationships constituted by the interplay of the data.... A graphic is never an end in itself; it is a moment in the process of decision-making._

- Bertin (1981, p. 16)

Information visualization is the design and construction of interactive graphic representations of information. The field combines principles from cognitive science and computer graphics to support explicit visual representations of conceptual understandings. The field evolved in reaction to the exponential growth
in computational power, affordable computer graphics software, increased access to personal computers and the ubiquity of information available online.

Why should online learning environments use information visualization to represent nontraditional students’ conceptual understandings? Information is now ubiquitous and instantaneously accessible. As the volume and complexity of new information increases, nontraditional students may require more than text-based descriptions of their conceptual networks to effectively update their skills and understandings. Visual representations of conceptual understandings are significantly different from linear textual representations. Visual objects are easily recognized, minimal use of words and graphics makes it easier to scan for a concept or conceptual relation, and visual representations may allow for development of a global understandings of how students’ view their understandings (Nosek & Roth, 1990). Nontraditional students may also require informative representation methods and tools that allow them to visualize their existing knowledge, manage gaps in their understandings, and share their understandings with teachers and students in their online learning community.

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35 Tufte (1990) suggested students thrive on “visual, information thick worlds because of [students’] marvelous and everyday capacity to select, edit, single out, structure, highlight, group, pair, merge, harmonize, synthesize, focus, organize, condense, reduce, boil down, choose, categorize, catalog, classify, refine, abstract, scan, look into, idealize, isolate, discriminate, distinguish, screen, sort, pick over, group, pigeon hole, integrate, blend, average, filter, lump, skip, smooth, chunk, inspect, approximate, cluster, aggregate, outline, summarize, itemize, review, dip into, flip through, browse, glance into, leaf through, skim, glean, synopsize, winnow wheat from chaff, and separate sheep from the goats” (p. 33).
Graphic Organizers

A graphic organizer is a visual representation of organized conceptual understandings. Types of graphic organizers include: semantic networks (Rumelhart, 1977), concept maps (Novak & Gowin, 1984), mind maps (Buzan, 1994), hyperbolic browsers (Lamping, et al., 1995), cone trees and perspective walls (Rao & Sprague, 1998), and disk trees and time tubes (Chi et al., 1998) just to name a few. A graphic organizer is a way of structuring information, of arranging concepts and conceptual relations in a knowledge domain using signs (e.g., words) to represent abstract ideas. Graphic organizers require students to engage their existing perceptions (Novak, 1985) and their misconceptions and gaps in understanding (Metcalf & Shimamura, 1994) as they struggle to assimilate and/or accommodate new information into their conceptual frameworks. Graphic organizers may include multimedia materials, including visual and textual information and therefore may be beneficial to students with a wide range of learning types (Gardner, 1991), conceptions of learning and approaches to learning (Entwistle, 2000) and pre-existing knowledge. Graphic organizers are also effective at facilitating collaborative interaction as they can be used to facilitate work between students and teachers (Dent, 1985).

Problems with graphic organizers. First, it is important to note graphic organizers are like any other visualization of abstract concepts. They are not perfect representations of reality, but rather provide one of multiple views of reality. For example, various cartographic projections (e.g., cylindrical, conical, azimuthal or
planar) are employed to give alternate views of the physical world in two-dimensional space. These views are useful, but distorted nevertheless (Wandersee, 1990). If representations of the world in the form of maps distort reality, why even attempt to use them to represent students’ complex conceptual understandings?

Robinson (1980) noted, “The projection constitutes a systematic reference frame” (p. 58) within which the map creator presents her interpretation of concepts, events and objects (real or abstract) in the world. In other words, the best students or teachers can do is to represent their biased approach to the intended function of their “maps” and acknowledge graphic organizers are approximations of their perceived reality. Monmonier (1977) went so far as to contend “distortion is necessary in order that the map reader be permitted to comprehend the meaning of the map” (p. 7).

Second, graphic organizers may not be helpful for a student who’s preferred learning style is not visual. Gardner’s (1991) Theory of Multiple Intelligences argued there are seven distinct learning styles with which students approach new information, and “visual” (Gardner refers to this style as “spatial”) is only one. Because students’ primary learning style at least partially determines how they react to and deal with new information, providing mental images of information cannot be expected to work for all nontraditional students.
Research on Information Visualization

The information visualization field emerged as researchers sought methods and tools to develop graphic representations of abstract information through the use of interactive computer graphics and visualization techniques (Card et al., 1996, 1999). Researchers have explored the varied effects of picturing knowledge on learning. Card (1991) reported two-dimensional and three-dimensional visual reasoning was more efficient than linear verbal language. Petre and Green (1993) extended Card’s findings with evidence that "seeing" information graphically is an acquired skill. In contrast to Nosek and Roth (1990), Petre and Green also found students could solve problems faster with textual languages than with graphical languages. However, they concluded that although students seemed to have to work harder to utilize graphical information, the graphical structure proved much richer for expert users. This finding suggested nontraditional students may benefit from visualizing their understandings as they may be considered “experts” by virtue of their previous degrees and multiple years of professional experience. However, Petre and Green’s findings suggested information visualization is an acquired skill and therefore may take time before nontraditional students can benefit from a new information visualization tool.

Additional research explored how information visualization affected students’ conceptual change processes. West and Pines (1985) found picturing knowledge may prompt students to integrate existing understandings with new information vis-à-vis conceptual change processes. Novak (1993) argued visual
networks of concepts and conceptual relations may be efficient at chunking
knowledge to increase the limitations of students’ short term memory. Novak and
Gowin (1984) reported visualizing one’s ideas reinforced and clarified students’
existing understandings as students recreated, in their own visualizations, what they
had learned. They also reported that visualizing understandings assisted students in
identifying misconceptions and gaps in their understandings.

Research on graphic organizers. The literature describes several learning
outcomes of using graphic organizers. Flood and Lapp (1988) found creating
graphic organizers to illustrate the organization of new information aided in student
comprehension. Dunston (1992) elaborated on this and reported that when students
were presented with graphic organizers before reading, comprehension and recall of
new information was significantly improved. Robinson and Kiewra (1995) found
students provided with graphic organizers constructed more complex conceptual
relations and were better able to transfer text knowledge than those who were
provided with text based outlines. Corkill (1992) and Robinson (1998) similarly
reported students performed better on assessments measuring understanding of text
information referenced in graphic displays. Robinson and Skinner (1996) introduced
the idea of graphic organizers’ spatial arrangement of concepts when they found
graphic organizers enabled students to coordinate conceptual relations more quickly,
and possibly with less effort (Robinson & Schraw, 1994) than if students viewed a
linear display (e.g., text outline) of the same information. Dunston (1992), however,
reminded designers intending to implement graphic organizers that they are most
effective when students received training on how to construct images of their conceptual understandings and used these visualizations in course assignments.

**Research on visual collaboration.** Graphics, according to Bertin (1981), have at least two distinct uses. First, as the means of communicating information, in which case the student possesses existing knowledge. Second, for graphical processing, in which case the student uses the manipulation and perception of graphical objects to process new information vis-à-vis conceptual change processes. Research on information visualization interfaces suggests visual understandings may benefit not just from well designed visual representations, but also from meaningful interactions with those representations (Card et al., 1999; Chuah & Roth, 1996; Tweedie, 1997). In decision making (Bertin, 1981) and sense making (Russell et al., 1993; Dervin, 1992, 1998) useful information is constructed by interacting not only with the information, but also by working with other students.

As students and teachers create graphic organizers collaboratively, they may learn from each other as they extend their collective interpretations. Linking collaborative learning and graphic organizers may benefit students in several ways. McTighe (1992) argued graphic organizers provide a focal point for collaborative constructions of knowledge by offering a common frame of reference for dialogue. A completed graphic organizer provides a “group memory” or tangible product of the learning community’s collective conceptual understandings. Students are encouraged to expand their own understandings by considering different points of view made explicit as the learning community reviews and validates new conceptual
relations and conceptual structure. Further, the articulation of reasoning required by the use of a graphic organizer may help to render nontraditional students’ implicit understandings explicit so all students may leverage the benefits of social constructions of understandings.

**Graphic Organizer for Nontraditional Students**

While using graphic organizers to visualize students’ understandings in collaborative learning environments seem potentially useful, designers of online learning environments must not lose sight of the central problem facing nontraditional students. Conceptual change within students’ individual and the learning community’s collective understandings should enable all students to continually update their understandings. As such, the choice of which graphic organizer to select should be driven by “a commitment to support the learning objectives and … interaction between students, teachers and learning [resources]” (Maxwell & McCain, 1996, p.13). Researchers at the North Central Regional Educational Laboratory identified six concepts of technology functionality that could be used to design and/or select appropriate information imaging educational technology tools. The educational technology should be: (1) *accessible*, students must be able to get to, access, and know how to utilize the technology; (2) *transparent*, enabling students to focus on their learning goals and not on the hardware, software or network; (3) *provide localized control*, allowing for collaborative learning and shared resources through a distributed network architecture; (4) *support learning activities*, providing complex, ill-structured
learning problems in authentic learning environments; (5) *easy to use*, including user friendly software accompanied by training on both the educational technology and its pedagogical uses; and (6) *functional*, providing educational technologies that enable students to construct conceptual frameworks using multiple modes and displays of information.

With these design considerations in mind, the remainder of this section explores concept mapping as an information visualization educational technology to enable nontraditional students to visualize, manage and share their existing articulations and conceptual change processes in nontraditional collaborative online learning environments.
Concept Mapping

To concept map is to construct a schematic, networked representation of one’s understandings. Wandersee (1990) argued map making has a rich history:

The earliest known map was found inscribed on a bone artifact at Mezhirich, USSR and dates back to about 10,000 BC (Hellemans & Bunch, 1988). It seems to show the geographic area immediately surrounding the site at which it was found…. South Sea Islanders invented stick charts… to map the currents, prevailing winds, and islands they encountered in their journeys across hundreds of miles of open sea. The technique was fully developed even before they had any written language (Wurman, 1989). In the early 1800s, Admirals Parry and Ross were startled to find Eskimos, whom they met on their expeditions to the Arctic, were not only able to understand the explorers’ navigational maps but could even supply important information to improve them (Daly, 1879)…. From early on, humans have sought to explore and map their world of experience on two and three-dimensional visual representations. Once mapped, new land or water was no longer considered terra incognita but terra cognita, a region known to humankind. Thus, “to map” has always meant “to know” (p. 923).

Concept mapping is a methodology and educational technology tool for explicitly visualizing, managing and sharing conceptual understandings. Concept maps, however, were not the first attempt by researchers to visually represent students’ conceptual frameworks. Prior examples include: association memory from symbolic information processing theorists (Newell, 1977), entailment structure of conversation theory (Pask, 1976), frame-system theory for memory (Minsky, 1977), and semantic networks (Rumelhart, 1977). Concept mapping differs from these other models in that Novak (1985) intended concept mapping to be a learning tool designed to help students to explicitly and visually represent their existing
understandings. Concept maps are explicit, overt representations of students’ conceptual frameworks. They “allow teachers and students to exchange views on why a particular propositional linkage is good or valid, or to recognize missing linkages between concepts that suggest a need for new learning” (Novak & Gowin, 1984, p. 19).

The beginnings of concept mapping can be traced back to Novak’s (1972) research at Cornell to better understand children’s scientific conceptual change processes. Novak and colleagues were troubled that their paper and pencil tests did not validly measure children’s understandings. That is, Novak sat down with each child and asked her what she meant by her answers. What he found was little correspondence between his interpretations of a child’s response and the meaning the child expressed. Over time, Novak (1984) hypothesized that the meaning a child possesses of any one construct is not an all or nothing acquisition, but rather “a growing set of propositional linkages between the concept of concern and other related concepts” (pps. 94-95). He decided he needed a new assessment tool that would allow children to explicitly express their varying degrees of understanding and track their conceptual changes over time. This need prompted Novak and his team to develop concept mapping.
Concept Maps as Conceptual Frameworks

Concept maps are graphic organizers representing students’ conceptual frameworks where words (i.e., signs, typically enclosed in a box) represent concepts, and links represent conceptual relations. The concepts and the links are labeled on the concept map using words to signify what they represent. Conceptual relations may be one-way, two-way or non-directional. Conceptual relations can also be used to show multi-way connections by linking multiple concepts to a single conceptual link node (Novak, 1990). The concepts and the links may be categorized among hierarchies on a concept map and may be positioned to indicate causal relations among concepts.

In the context of concept mapping, propositions are statements about how two or more concepts are related. Novak and Gowin (1984) argued: “a concept map is a schematic device for representing a set of concept meanings embedded in a framework of propositions" (p. 15). Propositional statements are meaningful because these semantic units can be read as a statement that provides meaning to the conceptual relation(s). Based on Ausubel’s (1968) assimilation theory, “meaningful” learning (i.e., deep processing) occurs with the assimilation and/or accommodation of new information and new conceptual relations, which subsequently form propositional statements, into students’ existing conceptual frameworks. Figure 4 is an example of a concept map that visualizes the structure of concept maps and illustrates some characteristics of this information visualization tool.
Figure 4. Concept map of concept mapping.
Research on Concept Mapping

Research by Ausubel, Novak, Gowin and multiple other researchers\textsuperscript{36} argued the learning benefits of concept mapping are widespread and not limited to any particular sub-group of students. Primary school students are capable of developing and explaining concept maps (Novak & Gowin, 1984; Novak, 1990; White & Gunstone, 1992), as are middle school students (Novak & Gowin, 1984; Novak et al., 1983; Symington & Novak, 1982; White & Gunstone, 1992). Anderson and Huang (1989) found students of varying ability can successfully use concept maps.

Deep / meaningful learning. Downing and Morris (1984) argued concept mapping supported deep / meaningful learning by helping students to assimilate new information more effectively by providing a logical conceptual process to think through, reflect on, judge the content of the new information, and visualize and manage the new conceptual relations. Novak, Gowin and Johansen (1983) argued concept mapping helped students learn reflectively because the concept map acted as a conceptual filter through which new information could be assessed critically, organized and viewed in the student’s larger conceptual framework.

\textsuperscript{36} Research on concept mapping has also explored the tool’s multiple uses: as a tool for research, particularly to investigate students’ existing conceptual understandings and changes in conceptual frameworks (Dana, 1993; Inger, 1995, Koch, 1986; Markham, Mintzes & Jones 1994; Pendley, Bretz & Novak, 1994; Demastes et al., 1995; Wilson, 1994); curriculum development (Edmondson, 1995; Pearson & Hughes, 1986); assessment (Schick, 1991; Schreiber & Abegg, 1991); as a metalearning strategy (Wandersee, 1990); identifying gaps and misconceptions in students’ conceptual understandings (Songer & Mintzes, 1994; Trowbridge & Wandersee, 1994); and for promoting meaningful learning (Novak, Gowin & Johansen, 1983; Okebukola & Jegede, 1988; Clark & James, 1993; Lehman Carter & Kahle, 1985; Mayer, 1989; Roth, 1994).
Novak and Gowin (1984) further suggested concept maps were explicit visualizations of students’ understandings. As such, concept maps could be used collaboratively to share understandings, debate views, and identify misconceptions and gaps in their understandings.

Collaborative learning. Concept mapping may also support specific collaborative learning goals. Research suggests concept mapping may be easily and quickly taught to students. Once taught, the technique can be used in large learning communities with minimal assistance from teachers (Wallace & Mintzes, 1990; White, 1987). Davidson (1982) suggested students compare one another's maps and discuss the differences. Mayer (1989) argued concept maps helped students transfer assimilated information to more easily solve new learning problems and to provide an efficient and concise schematic summary of students' learning. Stice and Alvarez (1987) reported concept mapping gave students a sense of confidence in manipulating and restructuring new information, increased concentration and focus on the new information, and improved students’ intrinsic motivation for self-regulated learning37.

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37 Increased confidence, concentration and self-regulated learning are all key factors in individual accountability, the third element of Johnson, Johnson & Holubec’s (1984) path to successful collaborative learning.
Validity and Reliability of Concept Mapping

Over two hundred studies in science education have tested concept mapping in one form or another (Novak, 1998; Novak and Wandersee, 1990) and several of these studies have explored the validity and reliability of concept mapping as a tool for exploring students’ existing conceptual understandings and conceptual change processes (Markham, Mintzes & Jones, 1994; Pearsall, Skipper, & Mintzes, 1997; Ruiz-Primo & Shavelson, 1994; Songer and Mintzes, 1994; Wallace and Mintzes, 1990). While early studies (Novak et al., 1983) found low correlations between the complexity of students’ concept maps and other measures of achievement, more recent research (Shavelson et al., 1993) reported correlations between concept maps and standard measures of achievement “at or above 0.50” (p. 22). Wilson (1993, 1994) examined concept maps on chemical equilibrium constructed by senior high school students. Wilson found moderate significant relationships (.56, p<.02) between measures of hierarchical organization and complexity and conventional measures of achievement.

Liu and Hinchey (1993) explored the construct validity and internal consistency of concept mapping scores in a study of seventh grade science students. Correlations between concept mapping scores and formal test scores were found to be .44 (p<.05). Wallace and Mintzes (1990) and Markham et al. (1993) studied the concurrent validity of concept mapping in undergraduate biology courses. Wallace and Mintzes (1990) gave elementary teachers 45 minutes of instruction on marine life zones. In comparison to the control group, which received equivalent instruction
on an unrelated topic, the elementary teachers demonstrated significant (p<.01) gains on all measures of structural complexity in their concept maps of marine life zones. Markham et al. (1993) studied a group of advanced college biology majors and a second group first year undergraduates enrolled in a non-majors biology course. Students were asked to concept map their understandings of mammals. Significant differences (p<.01) favoring the advanced group were found, and the students’ ideas represented in the concept maps reflected the same conceptual complexity observed in verbal interviews with the students. In a similar study, Anderson and Huang (1989) found a .69 correlation between concept map scores and corresponding short answer tests.

Novak, Gowin, and Johansen (1983), however, suggested concept map complexity scores did not correlate significantly with traditional measures of learning such as multiple choice tests. They found students’ concept mapping scores were not significantly related to students' SAT scores. These findings might suggest concept mapping may represent different understandings than those captured by conventional assessment instruments.

The differences between correlations found in more recent studies (Anderson & Huang, 1989; Shavelson et al., 1993) and those reported in earlier concept map research (Novak et al., 1983) support White and Gunstone’s (1992) point that concept map scores resulting from different scoring methodologies reflect different measures of students’ capabilities. Subsequently, different levels of correlational significance were found when comparing concept maps scores with traditional
assessment measures. For example, the standards for evaluating the achievement of students in the Anderson and Huang (1989) study was the “right” answer, that is, the closer a student’s map mirrored the teacher’s “expert map,” the higher their concept map score. This pedagogical view is little different from traditional, transmissional assessment and does not support the creative and informative capabilities of concept mapping. It is important to understand and focus on the theoretical rationale for one’s concept map scoring method in order to properly evaluate the success of the educational tool and/or pedagogy in helping students to accomplish their learning goals.

Digital Concept Maps

As online learning environments are, by definition, visual, any concept map tool used by online nontraditional students needs to produce digital concept maps. While the potential learning applications of concept mapping are well documented in the research literature, the digitization of concept mapping may enhance and add to these capabilities.

Conversion and storage. Digital concept mapping allows for digital storage of concept maps. Once a concept map is created digitally, the software allows the student to convert the concept map into multiple derivative electronic formats. These formats may include digital images, a text outline or even a navigable web site. These derivative versions of the concept map can then be stored, sent, manipulated, used, printed, edited, reviewed, reconstructed, and/or deleted just like any other digital file.
Sharing digital concept maps with other students is further facilitated by learning management systems (e.g., WebCT® or Blackboard®), which allow students to access their course materials and other students’ concept maps from any Internet connection.

**First draft principle.** One benefit of digital concept maps may be the “first draft principle” of concept mapping. Students often struggle with the first draft of a paper. It is often beneficial to employ the simple problem solving strategy of writing down key ideas without worrying about overall conceptual structure, coherence, transitions, grammar or spelling of a paper. Similarly, students should be encouraged to “throw” new concepts and probable or hypothesized conceptual relations onto their concept maps. Rather than hold new information in abeyance (Chinn & Brewer, 1993) in one’s short-term memory, planning to deal with it later, students should be shown the fluid impermanence of concept nodes and conceptual links on a digital concept map. It does not matter where students initially map new concepts as the concepts, conceptual relations, cross-links and propositional statement labels can be restructured at any time with no substantial loss of investment in time or effort.
The first draft principle of concept mapping has three guidelines for students constructing concept maps. First, the concept map should always feel like a rough draft. Students are more likely to take risks of assimilation and/or accommodation if they do not view the concept map as being “locked down.” Second, students should experiment freely with integrative reconciliation vis-à-vis cross-links between seemingly disparate concepts. Third, as concept mapping facilitates explicit images of students’ knowledge bases and allows students to think and act flexibly by moving concepts and conceptual links in random ways (Spiro & Jehng, 1990), students with flexible learning tools at their disposal may be more likely to share their concept maps with other students.

**Conceptual change tool.** If concept mapping is used to map students’ conceptual understandings, then concept map structural complexity changing over time might be viewed as students’ conceptual change processes. A more “complex” concept map therefore represents more complex understandings. Conceptual change, then, might be thought of as both the process and the outcome of changes in understandings over time as indicated by changes in students’ concept maps.

Just as the first map of new territory enables subsequent explorers to test, amend and improve on their maps (Wandersee, 1990), so too might students iteratively restructure their conceptual frameworks vis-à-vis conceptual change processes to improve their conceptual understandings of new domain territory. Research has shown students bring relevant conceptual frameworks of varying degrees of quantity and quality to new learning scenarios (Helm & Novak, 1983;
West & Pines, 1985; Novak, 1987). The challenge, therefore, is not only to help students make their existing notions visually explicit, but more important, to help them modify their existing conceptual frameworks that may contain misconceptions, gaps in understanding or naive conceptual relations. The practice of revisiting concept maps serves the important function of encouraging students to reflect on their existing understandings (Chi, Glaser & Farr, 1988). The method enables students to consider what they think they know in light of new information. Metcalfe and Shimamura (1994) argued the goal of this iterative, self-reflexive, longitudinal assessment was to encourage students to monitor their own learning and to struggle with and resolve misconceptions and gaps in their understandings.

Snapshots of students’ concept maps taken over the course of an academic semester might be useful to determine the type and rate conceptual change processes enabled when nontraditional students use concept mapping to share their conceptual understandings in a collaborative online learning environment.

Communication tool. There are two key processes, which must occur if a concept map is to fulfill its role as a dialogical communication tool (Dent, 1985). First, the constructor of the concept map must encode new conceptual relations. Only potentially meaningful, contextually appropriate information should be included on a map (Guelke, 1976) that is intended to be shared in a learning community. Second, the concept map-reader must be able to retrieve the meaning, which was encoded by the concept map constructor.
Opportunities for communication are present at both processing points and may
serve to challenge students’ comprehensions, create conceptual relations links and
cross-links, and to visualize new information held in abeyance (Cuff & Mattson,
1982).

**Access socially distributed understandings.** Johnson et al. (1981) argued
when students work collaboratively to assimilate and/or accommodate new
information, positive cognitive and affective outcomes result. There may be distinct
learning opportunities created when concept mapping is used in collaborative online
learning environments. When students share their understandings vis-à-vis concept
maps, all students may leverage the socially distributed understandings available in
their online learning community.

In addition to getting students to share declarative knowledge and procedural
understandings in online learning communities, the real challenge is to make one’s
tacit knowledge explicit. If online collaborative learning communities enable
students to leverage social construction of understandings by sharing individual
declarative, procedural and tacit knowledge, concept mapping might provide a
methodological opening to access the wealth of untapped socially distributed
knowledge inherent in a nontraditional learning community. See Figure 5 for a
model of how students might use concept maps to make declarative, procedural and
tacit knowledge explicit so it can be shared.
A concept map produced by one student represents one possible way to structure conceptual understandings. This learning product can and should be shared with others. This sharing of expertise and information vis-à-vis concept mapping and collaborative learning in an online learning environment may help nontraditional learners continually update their skills and understandings in their workplace.
Figure 5. Accessing socially distributed understandings within online learning communities as enabled by concept mapping.
Summary of the Literature

Chapter Two reviewed the literature of three fundamental constructs that provide the theoretical framework for this study. They included social construction of understandings, conceptual change, and visualization of conceptual understandings. The first section, social construction of understandings, examined collaborative learning as a possible pedagogy to enable nontraditional students to socially construct understandings in online learning communities. The section began with a discussion of constructivism and more specifically, sociological constructivism as the theoretical base for online learning communities and collaborative learning. The authentic learning requirements of nontraditional learners were stressed in Lave and Wenger’s (1991) situated learning and in Sticht’s (1976) functional context theories. Both theories argue learning is a function of the activity, context and culture in which it occurs. Further, learning requires social interaction and collaboration, and must be made relevant to nontraditional students’ professional lives. Online learning communities were then presented as the learning space within which social construction of understandings might occur. The section concluded with an analysis of collaborative learning and its associated learning benefits and problems.

The second section, conceptual change, explored how students learn based on what they already know. The section focused on comprehending how students’ conceptual frameworks are structured and how their understandings changed when students are presented with new information. This section also emphasized, through
schema, scaffolding, and conceptual change theories, that what students bring with them to the learning environment in terms of their existing understandings and their approaches to learning is critical to designing appropriate learning environments.

The third section, visualization of conceptual understandings, attempted to bridge the first two sections by proposing a tool and method by which nontraditional students could visualize, manage and share their existing understandings and monitor their ongoing conceptual change processes. This section explored information visualization theory to better understand how graphic organizers might support explicit visual representations of students’ knowledge bases. After reviewing multiple graphic organizers, concept mapping was proposed as a potential tool and method to both allow nontraditional learners to construct digital, schematic representations of their understandings, and as a method to share those constructions with other students in an online learning community.

Theoretical Research Question

How do nontraditional students’ learning and technology experiences affect how they use information visualization tools in their online learning environment?
CHAPTER 3: METHODS

This chapter describes the general methodology used in this study. Five major sections organize chapter three as represented in Figure 6. The research context section includes a description of the online learning environment, the subjects including the removal of one student, and the roles of the researcher and the teacher. The research questions and hypotheses section lists the study’s two research questions and seven research hypotheses. The operational definitions of constructs section details how each of the study constructs is defined, operationalized and measured. The procedures for data collection section describes the procedures used to collect data on each of the constructs. This section also includes instructions provided to subjects on how to concept map. The chapter concludes with the procedures of data analysis section that includes the procedures used to construct and define the learner types as well as procedures for data analysis of the research hypotheses and the post study interviews.
Figure 6. Concept map of chapter three: methods.
Research Context

This study examined the population of the first class of the Nontraditional Doctor of Pharmacy (NTPD) program at The Ohio State University. The study was held during the Pathophysiology and Therapeutics III course over the 2002 summer academic semester. The NTPD is an online degree program designed to provide the opportunity for practicing pharmacists at the baccalaureate level to update their pharmaceutical care understandings and skills and obtain the PharmD degree online.

Subjects / Participants

Students’ demographic data were acquired from their NTPD program application forms. All 26 students lived and practiced pharmacy in Ohio. Eighteen of the students were female. Students’ ages ranged from 25 to 51 years with a mean age of 33. Seventeen students classified themselves as Caucasian, five as Asian and four as African American. Twelve worked in retail pharmacies, 12 in hospital pharmacies and two in managed care settings. Their number of years practicing as a pharmacist ranged from one to 28 years with a mean of 9.6 years. Students’ entering grade point averages (GPA) ranged from 2.8 to 3.8 with a mean GPA of 3.2.

Students were clustered into collaborative groups of five students each at the beginning of the NTPD program. These work groups communicated weekly in live audio conferences to work on collaborative group assignments. Students were therefore very familiar with other students in their work groups at the time of this study.
Removal of Student from the Study

One student was removed from all research hypotheses analyses. When the student’s concept maps were scored, the scores were skewed high because the student created “upside down” concept maps. The final results are therefore based on 25 students.

Role of the Researcher

As the Director of Educational Technology and a senior member of the team that designed, developed and delivered the NTPD program, the researcher had unique access to these students. The researcher had opportunities to introduce educational technologies into students’ online learning environment, train students and teachers on collaborative learning in learning communities and influence assignments in the NTPD curriculum. The combination of these opportunities made these students and the online learning environment ideal candidates for this study. The researcher managed technical support for the concept mapping software, collected survey responses, conducted interviews, trained the two coders and scored all of the concept maps.

Role of the Teacher

The teacher for the course was the Director of the Nontraditional PharmD program. The teacher gave the researcher permission to introduce and study concept mapping with the 26 students. The teacher was the course coordinator, graded all

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The student’s “upside down” maps complexity scores were skewed high because configurations which would normally be scored a single instance of branching (three points) were instead scored as multiple cross-links (10 points). See the Recommendations for Methods and Measurement section in Chapter five for an explanation of this problem.
course assignments, hosted a majority of the online workshops and constructed one of the teacher scaffolded concept maps. The teacher also had a strong collaborative approach to learning.

Research Questions and Hypotheses

This section presents the two research questions and the seven hypotheses guiding this study.

Research Questions

Q₁: How can online nontraditional students be represented as learner types based on their approaches to learning and conceptions of learning, self efficacy with using computers, and computer use/experience?

Q₂: What are the relationships between and among learner types, their collaborative behavior and their academic performance?

Figure 7 is a concept map of the conceptual relationships between the theoretical research question, how nontraditional students may be represented as learner types and the relationships between the learner types and their collaborative behavior and academic performance.
Figure 7. Concept map of the theoretical research question and the two research questions.
Research Hypotheses

$H_1$: The complexity of students' concept maps is positively correlated with: sharing maps, reviewing maps, frequency of mapping, deep and strategic approaches to learning, self efficacy with computers, computer use/experience, final grades, conceptions of learning as transforming, preferences for teaching which encourages understanding, and the use of teacher scaffolded concepts.

$H_2$: Sharing maps is positively correlated with reviewing maps and with a deep and strategic approach to learning.

$H_3$: Reviewing maps is positively correlated with the deep and strategic approaches to learning.

$H_4$: Students’ maps will become increasingly more complex over the semester.

$H_5$: Growth in the complexity of students’ maps will increase over the semester and will accompany periods of both assimilation and accommodation.

$H_6$: Computer use/experience is positively correlated with students’ self efficacy with computers.

$H_7$: Final grade is positively correlated with the deep and strategic approaches to learning.

See Figure 8 for a concept map of the hypothesized research construct correlations.
Figure 8. Concept map of hypothesized research construct correlations.
Operational Definitions of Constructs

This section introduces the major study constructs and examines how each construct is defined, operationalized and measured. Each construct is defined based on the rationale of the study and its supporting literature discussed in chapter two. The instruments, including indices and scale items, used to measure these constructs are listed in this section. The reliability results for all measures are presented in chapter four. Any data transformation, standardization or measurement issues are also discussed in this section.

**Concept Map Complexity Definition**

Concept Map Complexity is a compilation score of the number of concepts, conceptual relations, branching, levels of hierarchy and cross-links in a student’s concept map. Concept maps were scored for complexity using Novak and Gowin’s (1984) scoring procedure as modified by Markham et al. (1994). Markham and colleagues (1994) found students’ conceptual understandings revealed by concept maps reflected basically the same conceptual structure as that seen in interviews and picture sorting tasks.

The point values assigned to each scoring category were based on the relative importance of each structural characteristic. For example, each instance of a cross-link was assigned ten points, a value reflecting the relative importance assigned to integrative reconciliation which cross-links are assumed to represent in concept mapping. See Table 2 for a summary of the operational definitions of study constructs and measures.
<table>
<thead>
<tr>
<th>Construct</th>
<th>Operational Definition</th>
<th>Measure</th>
</tr>
</thead>
</table>
| Concept Map Complexity          | Compilation score of the number of concepts, conceptual relationships, branching, levels of hierarchy and cross-links in a student’s concept map.                                                                                      | Concept = one point  
Conceptual relationship = one point  
Branching = three points  
Level of hierarchy = five points  
Cross-link = ten points |
| Collaborative Learning          | How many times students shared their maps, how many times they reviewed others’ maps, and whose maps they reviewed.                                                                                                        | Sharing Maps Scale Item  
Reviewing Maps Index  
Reviewed from Whom Index                                                                   |
| Conceptions of Learning and Approaches to Learning | Students’ conceptions of learning (learning as transforming vs. learning as reproducing), approaches to learning (deep, strategic, surface) and preferences for different types of courses and teaching (encourages understanding and transmitting information). | ASSIST Indices:  
  o Learning as Transforming  
  o Learning as Reproducing  
  o Deep Learning  
  o Strategic Learning  
  o Surface Learning  
  o Encourages Understanding  
  o Transmits Information |
| Frequency of Concept Mapping    | How many times students’ made changes to their concept maps.                                                                                                                                                          | Frequency of Mapping Scale Item                                                              |

Table 2 (Continued)

Summary of Operational Definitions of Constructs and Measures
<table>
<thead>
<tr>
<th>Construct</th>
<th>Operational Definition</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of Conceptual Change</td>
<td>Changes in students’ total concept map complexity scores over the course of the study.</td>
<td>Measure changes in students’ total concept map complexity scores over the course of the study.</td>
</tr>
<tr>
<td>Type of Conceptual Change</td>
<td><em>Assimilation</em> (ten or more concepts added to a map) and/or <em>accommodation</em> (addition or deletion of one or more concepts to the first, second or third hierarchical levels of a map).</td>
<td>Frequency of instances of assimilation and/or accommodation on students’ maps over the course of the study.</td>
</tr>
<tr>
<td>Teacher Scaffolded Concepts</td>
<td>Presence (including total number of instances) or absence of teacher scaffolded concepts in a map, complexity of hierarchy under the scaffolded concepts and the hierarchical position of the scaffolded concepts in the overall structure of the map.</td>
<td>Score maps for presence or absence of teacher scaffolded concepts, complexity of hierarchy under the scaffolded concepts and the hierarchical position of the scaffolded concepts.</td>
</tr>
<tr>
<td>Self Efficacy with Computers</td>
<td>Students’ self efficacy with using computers and learning new software.</td>
<td>Self Efficacy with Computers Index</td>
</tr>
<tr>
<td>Use/Experience</td>
<td>Students’ current computer use patterns and past experiences using computers.</td>
<td>Use/Experience Index</td>
</tr>
<tr>
<td>Final Grade</td>
<td>Final grade assigned to student at the end of the course. Grade was based on: quizzes, assignments, participation score, midterm and final exams.</td>
<td>Final Grade</td>
</tr>
</tbody>
</table>
One point was scored for each concept and one point was scored for each conceptual relationship. Three points were scored for each instance of branching\textsuperscript{39}. Five points were scored for each level of hierarchy\textsuperscript{40}. Ten points were scored for each conceptual cross-link\textsuperscript{41}. Additional scoring rules included: a “?” or a “blank box” was not scored as a concept, link or cross-link. However, a blank link could still function as a link and may have facilitated an “instance of branching” and was scored accordingly. See Figure 9 for a concept map instrument scoring example.

\textsuperscript{39} Branching was defined as: one or more concept(s) linked to one or more link(s) linked to multiple concepts. Coders examined each concept on each level of hierarchy and looked for instances of branching; specifically looking for multiple arrows coming from the same concept. Coders scored the concept (once) from which the branching occurs. If multiple concepts were involved in one instance of branching, it was scored as one instance of branching.

\textsuperscript{40} Coders counted all hierarchical levels (including top concept: “Patho 3”). Unlinked concepts did not count as a “level of hierarchy.”

\textsuperscript{41} Cross-links were defined as: links from different first, second or third hierarchy levels that converged on a single concept. Coders were instructed to look for two arrows converging on a single concept and highlight concepts. “Cross-link(s)” from both directions were scored. Coders were also instructed not to double score “cross-links” as “links.” If coders scored “cross-links,” they were instructed to score them as such; and then go back and subtract the total number of “cross-links” from the “links” total.
Scoring for this concept map:

Concepts (1 point) X 13 = 13
Conceptual links (1 point) X 9 = 9
Instances of branching (3 points) X 6 = 18
Levels of hierarchy (5 points) X 5 = 25
Cross-links (10 points) X 6 = 60
125 points

Figure 9. Concept map instrument scoring example.
Data Transformation and Standardization

Two changes to students’ concept maps were made prior to scoring their maps for complexity. First, the “auto layout” feature of the IHMC CMap® software was used to reorganize students’ maps into a standard “family tree” layout. This allowed the coders to view the hierarchical levels on students’ concept maps. While this reorganization did not change any concepts, links, or cross-links, it did put all students’ concept maps into a manageable, standard format that could be scored by the three coders. This hierarchical reorganization was selected due to the high variability in how students constructed their concept maps. See Figure 10 for an example of a student’s map before the auto layout reorganization and Figure 11 for the same student’s map after the auto layout reorganization.

Second, the first level concept “Patho 3” was added to all students’ concept maps. If students already had “Patho 3” as their first level concept, no change was made. The reason for this change was to control for these inconsistencies because “levels of hierarchy” and “cross-links,” two of the complexity scoring measures, and “type of conceptual change” were all affected by the levels of hierarchy on students’ concept maps. Standardizing the top “Patho 3” hierarchical level ensured all students received points for that first level of hierarchy. See Figure 11 for an example of a student’s map with the “Patho 3” added to the first level of hierarchy.
Figure 10. Student’s concept map before hierarchical reorganization.
Figure 11. Student’s concept map after hierarchical reorganization.

Scoring Same vs. Separate Concept Maps for Total Map Complexity

Eight students created a single (i.e. “same”) concept map for each concept mapping assignment. Students with “same” concept maps added to and changed this “same” map over the course of the study. See Figure 12 for an example of a student’s “same” concept map. Notice this student assimilated multiple disease states including Alzheimer’s disease, Parkinson’s disease, psychiatric disorders, epilepsy, pain, and toxicology onto a single concept map.
Seventeen students created a “separate” concept map for each assignment. See Figure 13 for an example of a student’s “separate” concept map. Notice this student has constructed her map to represent only her understandings of Alzheimer’s disease and does not include information from other areas of the curriculum.
Figure 13. Example of a “separate” concept map.

Same maps were captured over time and maps one, two, three and four were scored individually and received a total score for each individual map. Separate maps were also captured over time, but their scores were added to the previous maps’ score because each separate map did not contain the contents of the previous map. Separate maps were also reviewed to see if any individual separate map
changed over time. If a separate map did change over time, the change was scored toward the time (one, two, three or four) in which the change was recorded.

Defining Reliability on the Concept Map Scoring Instrument

Two coders were trained on the concept mapping scoring instrument. The two coders were trained to use the scoring instrument on five training concept maps. Each of these five maps were similar in style to the concept maps constructed by the 26 students, but different in content. See Figure 14 for an example of one of the concept maps that was used to train two coders on the concept map complexity scoring instrument.

The researcher and two coders scored one concept map from each of the 26 students to assess the inter-coder reliability of the concept map scoring instrument. An intraclass correlation coefficient was performed. The researcher chose a two-way mixed model with “absolute agreement” because each concept map was scored by three known coders, the coders were a fixed effect, and the concept maps contained the unknown random effect (see Shrout & Fleiss, 1979; McGraw & Wong, 1996).

42 Note the researcher scored every concept map collected in this study.
Figure 14. Example concept map used to train coders on the concept map scoring instrument.
Collaborative Learning Definition

Collaborative learning was operationalized using three distinct but related constructs: how many times students shared their concept maps, how many times students reviewed other students’ concept maps, and whose concept maps they reviewed.

How often Students Shared their Concept Maps

This construct was measured with the Sharing Maps scale item. The Sharing Maps and Reviewing Maps indices were based on Brown, Collins and Duguid’s (1989) theory of social construction of knowledge. How often students shared their maps with others and how often they reviewed others’ maps was an indication of sharing understandings in their learning community. The Sharing Maps scale item was represented by the following question:

- During the 16 weeks of Patho 3, how many times did you encourage other students to review your concept map(s) on the CMap-Exp server?

How often Students Reviewed other Students’ Concept Maps

This construct was measured using the Reviewing Maps index. This index measured the perceived value students found from reviewing others’ concept maps and if they made changes to their own concept map(s) based on the review. The Reviewing Maps index was constructed by summing the following scale items.

- After reviewing another student’s concept map on the CMap-Exp server, I always made changes to my concept map(s).
- Reviewing other students’ concept maps helped me to better understand and map my understandings of Patho 3.

43 The original Sharing Maps index had an unacceptable reliability of .21. Due to the low reliability score, a single scale item was selected to represent the concept.
After receiving an E-mail notice that a Professor's concept map was on the CMap-Exp server, I always reviewed the Professor's concept map. After reviewing a Professor's concept map, I always made changes to my concept map(s). Professors' concept maps helped me to better understand and map my understandings of Patho 3.

Whose Concept Maps did Students Review?

This construct was measured by using the Reviewed from Whom index. This index’s scale items were based on Lave and Wenger’s (1991) theory of situated learning. This index measured how often students reviewed concept maps from other students and their teachers. The Reviewed from Whom index was constructed by summing the following scale items:

- How many times did you review concept maps constructed by students in your group?
- How many times did you review concept maps constructed by students outside of your group?
- How many times did you review concept maps constructed by your Patho 3 Professor(s)?
- During the 16 weeks of Patho 3, how many times did you review other students’ concept map(s) on the CMap-Exp server?

Approaches to Learning and Conceptions of Learning Definitions

These constructs described students’ approaches to learning, conceptions of learning and preferences for different types of courses and teaching. These constructs were measured with Tait and Entwistle’s (1996) Approaches and Study Skills Inventory for Students (ASSIST) indices. The ASSIST constructs were measured with 67 scale items.
The ASSIST was broken down into multiple sub-constructs including: approaches to learning (deep, strategic and surface indices), students’ conceptions of learning (learning as transforming and learning as reproducing indices), and students’ preferences for different types of courses and teaching (encourages understanding and transmitting information indices). All ASSIST scale items were summed as suggested by Tait and Entwistle (1996). Scores on the three main approaches to learning were obtained by adding together the sub-index scores that contributed to each approach. Seven point Likert-type scales were used in both the pre and post surveys. Unless otherwise noted, scale items were measured from seven (strongly agree) to one (strongly disagree).

Tait and Entwistle’s (1996) findings on the approaches to learning indices had reliability scores at or above .8 and the preferences for teaching indices had reliability scores above .6. While McCune (personal communication, April 5, 2002) suggested not using the conceptions of learning indices due to their low reliability, they were included because the Learning as Transforming index was related to dialogic pedagogy and the Learning as Reproducing index was related to transmissional pedagogy.

All indices employed in the study were tested for reliability using Cronbach’s alpha. If reliability was found to be unacceptable, the construct was removed from the analyses. See Appendix A for the entire ASSIST instrument and Appendix B for the ASSIST scoring key.
Approaches to Learning

Students’ approaches to learning were measured with three separate indices: deep learning, strategic learning and surface learning. These three indices were created by summing the ASSIST sub-indices that contributed to each approach. See Appendix B for individual scale items for each of the sub-indices.

Deep learning. The deep learning index was constructed by summing the following sub-indices:

- Seeking meaning
- Relating ideas
- Use of evidence
- Interest in ideas

Strategic learning. The strategic learning index was constructed by summing the following sub-indices:

- Organized studying
- Time management
- Alertness to assessment demands
- Achieving
- Monitoring effectiveness

Surface learning. The surface learning index was constructed by summing the following sub-indices:

- Lack of purpose
- Unrelated memorizing
- Syllabus-boundness
- Fear of failure
Conceptions of Learning

Conceptions of learning was operationalized into two indices: Learning as Transforming and Learning as Reproducing. The Learning as Transforming index was constructed by summing the following scale items:

- Being able to use the information you’ve acquired.
- Understanding new material for yourself.
- Seeing things in a different and more meaningful way.
- Developing as a person.

The Learning as Reproducing index was constructed by summing the following scale items:

- Getting on with the things you’ve got to do.
- Building up knowledge by acquiring facts and information.
- Making sure you remember things well.

Preferences for Different Types of Courses and Teaching

Preferences for different types of courses and teaching was operationalized into two indices: Encourages Understanding and Transmitting Information.

The Encourages Understanding index was constructed by summing the following scale items:

- Professors who encourage us to think for ourselves and show us how they themselves think
- Exams that allow me to show that I’ve thought about the course material for myself.
- Courses where we’re encouraged to read around the subject a lot for ourselves.
- Books that challenge you and provide explanations that go beyond the lectures.
The Transmitting Information index was constructed by summing the following scale items:

- Professors who tell us exactly what to put down in our notes.
- Exams or tests that need only the material provided in our lecture notes.
- Courses in which it’s made very clear just which books we have to read.
- Books that give you definite facts and information that can easily be learned.

**Frequency of Concept Mapping Definition**

This construct described how many times students’ made changes to their concept maps. The Frequency of Mapping scale item was primarily based on social construction of knowledge (Brown et al., 1989) and situated learning (Lave & Wenger, 1991) theories. How many times students concept mapped was representative of them acting on and changing their understandings. The Frequency of Mapping was represented by a single scale item:

- During the 16 weeks of Patho 3, how many different times did you make changes to your concept map(s)?

**Type of Conceptual Change Definition**

Type of students’ Conceptual Changes were measured by defining the growth in the complexity of students’ concept maps as assimilation and/or accommodation three times over the course of the study (second mapping date, third date, and fourth date). This construct was based on Ausubel’s (1963) assimilation theory.

Operationally, an instance of *assimilation* was scored when ten or more concepts

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44 The original Frequency of Mapping index had an acceptable reliability of .80. This index, however, was not useful as the items differentiated under what circumstances and why students made changes to their concept maps. This study, however, wanted to understand how often students mapped.
were added to a map. An instance of *accommodation* was scored with an addition or deletion of one or more concepts to the first, second or third hierarchical levels of a map. These operational definitions of assimilation and accommodation were modified from the Pearsall et al. (1997) dichotomous scoring method.

**Rate of Conceptual Change Definition**

The Rate of Conceptual Change construct explored when, in the course of the study, students engaged in major additions to their understandings as represented as changes in the complexity of their concept maps. This construct was based on Chinn and Brewer’s (1993) work. Operationally, this construct was measured by analyzing changes in students’ total concept map complexity scores over the course of the study (second mapping date, third date, and fourth date) to determine if their concept maps increased or decreased in complexity over the course of the study.

**Teacher Scaffolded Concepts Definition**

Teacher scaffolded concepts were provided to students during weeks three (Alzheimer’s map) and seven (Anxiety / Depression map). This construct was based on Bruner’s (1960) scaffolding theory. Teachers created their scaffolded concept maps using the IHMC CMap® tool. Teacher scaffolded concepts were operationalized as teacher constructed concept maps containing high level Pathophysiology and Therapeutics III concepts.
Students’ use of teacher scaffolded concepts was measured by the presence (including the total number of instances) or absence of teacher scaffolded concepts in their concept maps, the complexity of the hierarchy under the scaffolded concepts, and the hierarchical position of the scaffolded concepts in the overall structure of the students’ maps.

**Self Efficacy with Computers Definition**

This construct measured students’ self efficacy with using computers and learning new software. These scale items were adapted from McCain et al. (1999) who found an acceptable reliability of .87. The Self Efficacy with Computers index was constructed by summing the following 14 scale items:

- I feel very competent using computers
- I am afraid of computers.
- I can use a computer without significant difficulty.
- I avoid computers as much as possible.
- I am often worried that my academic performance in the NonTraditional PharmD is hurt because of computer problems
- I easily learn to use new computer software programs.
- I can accomplish very technical tasks on a computer.
- Learning new computer software programs is very difficult to me.
- I feel incompetent when I try to use a computer.
- I get very frustrated and feel out of control when I can’t get my computer or software to work well
- Learning to use new services available through the Internet is easy for me.
- I often have difficulty getting new software to work right on my computer
- When I run into a computer problem, I feel confident in my ability to either fix it
- I am confident in my ability to use my computer to work on the NonTraditional PharmD
Computer Use/Experience Definition

The Use/Experience index measured students’ current computer use patterns and past experiences using computers. The original version of the computer use/experience index was measured with seven questions adapted from McCain et al. (1999) who found an acceptable reliability of .65 to .86 across a four-factor solution with traditional undergraduate students. The Use/Experience index was constructed by summing two scale items:

- How many years have you owned a personal computer?
- How many years have you been using computers for your education?

Final Grade Definition

A final course grade was assigned to students based on the total number of points a student had accumulated after completing the following activities: quizzes, assignments, participation score, a midterm and a final exam.

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45 In this study, the modified use/experience index had an unacceptable reliability of .04. The index was refined to a two scale item index.
46 Multiple choice quizzes were taken once weekly and were worth 20 percent of the grade.
47 One assignment was due every two weeks and was worth 30 percent of students’ grade. Students discussed their solutions and helped one another with any problems encountered in the previous learning module; and prepared a patient case prior to each online workshop. Some assignments required students to concept map their arguments before presenting to the class. Students’ four concept map submissions accounted for 30 points of their overall course grade.
48 A total of 10 percent of students’ grades was based on participation. Students received five percent of their grade based on online bulletin board and live online participation. They received an additional five percent based on the evaluations they received from their group members on how well they participated in and contributed to group activities and projects.
49 Each exam was worth 15 percent of the final grade.
Procedures for Data Collection

This section describes the procedures used to collect data on each of the study constructs. The section includes a description of the concept mapping instructions provided to students. Data were collected: in pre and post online surveys, by downloading students’ concept maps from a public concept map server, and through recorded audio post study interviews.

Concept Map Complexity Procedure

Students constructed concept maps using the Institute for Human and Machine Cognition at the University (IHMC) CMap® concept mapping software. The software was developed by Novak and colleagues at the IHMC of West Florida. The software is available online (no charge for educational use) at: http://cmap.coginst.uwf.edu. Students saved their concept maps on their computer and on the IHMC CMap® concept map server. Requiring students to save their concept maps to a public concept map server provided all students and the researcher with easy access to all students’ concept maps. Students’ four (or more) digital concept maps provided the data for these analyses. See Table 3 for a summary of the data collection procedures of the study constructs.
Construct Procedures for Data Collection

<table>
<thead>
<tr>
<th>Construct</th>
<th>Procedures for Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept Map Complexity</td>
<td>Students received concept mapping instructions and saved their maps on a public concept map server. The researcher downloaded the maps.</td>
</tr>
<tr>
<td>Approaches to Learning, Conceptions of Learning and Preferences for Teaching</td>
<td>Pre survey responses collected with WebCT® quiz tool.</td>
</tr>
<tr>
<td>Self Efficacy with Computers Use/Experience</td>
<td>Pre survey responses collected with WebCT® quiz tool. Additional data were collected in the post study interviews.</td>
</tr>
<tr>
<td>Collaborative Learning Frequency of Concept Mapping</td>
<td>Post survey responses collected with WebCT® quiz tool. Additional data were collected in the post study interviews.</td>
</tr>
<tr>
<td>Rate of Conceptual Change Type of Conceptual Change Teacher Scaffolded Concepts</td>
<td>These constructs used the same data collected for concept map complexity.</td>
</tr>
<tr>
<td>Final Grade</td>
<td>Collected from the WebCT® grade book.</td>
</tr>
<tr>
<td>Post study Interviews</td>
<td>Scheduled and conducted online, recorded interviews in OfficeHoursLive®.</td>
</tr>
</tbody>
</table>

Table 3

Summary of Data Collection Procedures
Concept mapping instructions for students. Students were given an instructional concept mapping CD\textsuperscript{50} (see Figure 15). The CD contained written instructions and accompanying instructional videos (see Figure 16) on how to install and use the concept mapping software. Two live audio chat sessions were held on the theory and use of concept mapping and collaborative learning in online learning communities. See the study timeline in Appendix E for a list of the instructions students received throughout the study.

(1) Introductory Lecture (2) Concept Mapping Instructions

Figure 15. Home page of concept mapping instructional CD.

\textsuperscript{50} Please contact the researcher for a copy of the instructional concept mapping CD.
<table>
<thead>
<tr>
<th>Title</th>
<th>Video</th>
<th>Word</th>
</tr>
</thead>
<tbody>
<tr>
<td><em><strong>Screen Resolution Settings (Do this FIRST!)</strong></em></td>
<td>Video</td>
<td></td>
</tr>
<tr>
<td>(1) CMap Install Instructions</td>
<td>Video</td>
<td></td>
</tr>
<tr>
<td>(2) Accessing CMap Servers and Concept Maps</td>
<td>Video</td>
<td></td>
</tr>
<tr>
<td>(3) Adding the &quot;CMap-Exp&quot; Server to CMap Software</td>
<td>Video</td>
<td></td>
</tr>
<tr>
<td>(4) Create a &quot;Project&quot; on your &quot;Local&quot; Server</td>
<td>Video</td>
<td></td>
</tr>
<tr>
<td>(5) Build and Edit your Concept Map</td>
<td>Video</td>
<td></td>
</tr>
<tr>
<td>(6) Saving your Concept Map</td>
<td>Video</td>
<td></td>
</tr>
<tr>
<td>(7) Export your Concept Map to &quot;gif&quot;</td>
<td>Video</td>
<td></td>
</tr>
<tr>
<td>(8) Modify Concept Map Style</td>
<td>Video</td>
<td></td>
</tr>
<tr>
<td>(9) Access and Save other Students' Concept Maps</td>
<td>Video</td>
<td></td>
</tr>
<tr>
<td>(10) Suggestions in Building your Concept Map</td>
<td>Video</td>
<td>Word</td>
</tr>
</tbody>
</table>

*Video Viewing Instructions:

Figure 16. Instructions page of concept mapping instructional CD.

Students were instructed to build their first concept map based on their existing conceptual understandings of Pathophysiology and Therapeutics III. Throughout the semester, students saved their concept maps to the public concept map server a minimum of four times. Students were periodically instructed to review their previous concept map and to either delete it and start over, or to restructure their concept map to reflect their changing understandings.
Students were also prompted via E-mail every two weeks to share their concept maps with other students and their teachers. By the end of the study, a minimum of four maps were collected from each student.

**Approaches to Learning, Conceptions of Learning and Preferences for Teaching Procedures**

Data from all ASSIST indices were collected in the pre survey using the WebCT\textsuperscript{®} quiz tool. Students logged into the WebCT\textsuperscript{®} server, entered the Pathophysiology and Therapeutics III course, clicked on the survey icon and filled out the online survey containing the ASSIST, and other indices’, scale items.

**Self Efficacy and Use/Experience Procedures**

Data from the Self Efficacy with Computers index and the Use/Experience index were collected in the pre survey using the WebCT\textsuperscript{®} quiz tool. Data on these constructs were also collected during the post study interviews.

**Collaborative Learning Procedures**

Data from the Sharing Maps scale item, Reviewing Maps index and the Reviewed from Whom index were collected in the post survey using the WebCT\textsuperscript{®} quiz tool. Data on these constructs were also collected during the post study interviews.

**Frequency of Concept Mapping Procedure**

Data from the Frequency of Mapping scale item were collected in the post survey using the WebCT\textsuperscript{®} quiz tool. Data on this construct were also collected during the post study interviews.
Rate and Type of Conceptual Change and Teacher Scaffolded Concepts Procedures

The rate of conceptual change, type of conceptual change, and teacher scaffolded concepts used the same data collected for concept map complexity. As such, there were no additional procedures for data collection for these constructs.

Final Grade Procedure

Students’ final grade was collected from the WebCT® grade book. A total percentage column in the grade book calculated the total number of points from students’ quizzes, assignments, participation scores, midterm and final exams. This percentage was translated into their final grade.

Post Study Interviews Procedure

Students were contacted via E-mail and scheduled for a 45 minute live interview session. The researcher met with each student online in OfficeHoursLive® and recorded students’ responses to the 41 interview questions using both written notes and Total Recorder® to digitally record their verbal responses.
Procedures for Data Analysis

This section describes the procedures used to analyze the data after they were collected. The section includes the procedures used to construct and define the learner types as well as procedures for data analysis of the research hypotheses and the post study interviews.

Procedures for Constructing Learner Types

One important factor in designing nontraditional online learning environments is to first understand the characteristics of the nontraditional student. The 26 students in this study were clustered into learner types based on the learning and technology experiences they brought with them to the course. Specifically, the clusters were based on data from the ASSIST, self efficacy with computers and use/experience indices.

To describe the learner types in a robust fashion, all 86 scale items from the ASSIST, self efficacy and use/experience indices were used to construct the learner types. Reliability on all 86 scale items was checked against past research and all indices had acceptable reliability. These same 86 scale items were also used to build indices for the constructs: deep learning, strategic learning, surface learning, self efficacy with computers and use/experience. There were, therefore, no analyses of learner type on ASSIST, self efficacy or use/experience constructs.

A Q-mode factor analysis was performed using 86 scale items. Q-mode factor analysis, also called “inverse factor analysis” seeks to cluster people rather than scale items (Stephenson, 1967). That is, in Q-mode factor analysis, rows are
scale items, columns are people, and cell data are students’ scores on the scale items. In Q-mode, the factors are clusters of people for a set of scale items. Q-mode factor analysis is performed when the number of subjects is small and the number of measures is large.

Defining Learner Types

The two learner types were clustered according to their factor loadings and were best understood in terms of the different and shared high, middle and low rated scale items between the two learner types. The ASSIST and self-efficacy with computers indices used a seven-point Likert-type scale. Scale items were measured from seven (strongly agree) to one (strongly disagree). The following scoring rubric was applied to the data to identify high (high>6), middle (3<middle<6) and low (low<3) item means. A Wilks Lambda test was run to identify on which scale items the two learner types differed and which items they shared. The following rubric was applied to group scale items as either shared (F<1.5) or different (F>1.5).

Procedures for Data Analysis of Research Hypotheses

Three types of statistical tests, means comparisons of constructs by learner type, bivariate correlations and repeated measures analyses, were run to analyze the seven research hypotheses. All research hypotheses analyses were run on 25 students. Due to the low N, all measures were examined for homogeneity of variance with the Levene statistic prior to statistical analyses. For those data with poor homogeneity of variance, the non-parametric Kruskal Wallis Test was used to look for significant differences in means comparisons and Spearman's rho was used.
to analyze bivariate correlations. If the direction of a relationship was hypothesized, a one-tail test was used. Unless otherwise noted, an alpha level of .05 was used for all statistical tests.

**H}_1: The complexity of students’ concept maps is positively correlated with: sharing maps, reviewing maps, frequency of mapping, deep and strategic approaches to learning, self efficacy with computers, computer use/experience, final grades, conceptions of learning as transforming, preferences for teaching which encourages understanding, and the use of teacher scaffolded\textsuperscript{51} concepts.

Students’ total concept map complexity scores were analyzed with the: sharing maps scale item, reviewing maps index, frequency of mapping index, deep learning index, strategic learning index, self efficacy with computers index, use/experience index, final grade, learning as transforming index and the encourages understanding index using means comparisons\textsuperscript{52} and correlation analyses. See Table 4 for a summary of the procedures used for data analysis of the research hypotheses.

\textsuperscript{51} This study was initially interested in analyzing students’ use of teacher scaffolded concepts, but after examination of the students’ concept maps, the second survey responses and the post study interview responses, this hypothesis was not pursued.

\textsuperscript{52} Note that the apriori constructs used to construct the learner types were not used in the means comparison analyses.
<table>
<thead>
<tr>
<th>Research Hypotheses</th>
<th>Procedures for Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H$_1$: The complexity of students’ concept maps is positively correlated with: sharing maps, reviewing maps, frequency of mapping, deep and strategic approaches to learning, self efficacy with computers, computer use/experience, final grades, conceptions of learning as transforming, preferences for teaching which encourages understanding, and the use of teacher scaffolded concepts.</td>
<td>Indices analyzed using means comparisons of constructs by learner type and bivariate correlation analyses.</td>
</tr>
<tr>
<td>H$_2$: Sharing maps is positively correlated with reviewing maps and with a deep and strategic approach to learning.</td>
<td></td>
</tr>
<tr>
<td>H$_3$: Reviewing maps is positively correlated with the deep and strategic approaches to learning.</td>
<td></td>
</tr>
<tr>
<td>H$_4$: Students’ maps will become increasingly more complex over the semester.</td>
<td>Friedman test to measure concept map complexity scores and percentages of total complexity over time. Repeated measures analysis to test for interaction effects by learner type.</td>
</tr>
<tr>
<td>H$_5$: Growth in the complexity of students’ maps will increase over the semester and will accompany periods of both assimilation and accommodation.</td>
<td>H$_5$ also analyzed instances of assimilation and accommodation on students’ maps over the course of the study.</td>
</tr>
<tr>
<td>H$_6$: Computer use/experience is positively correlated with students’ self efficacy with computers.</td>
<td>Indices analyzed using means comparisons of constructs by learner type and bivariate correlation analyses.</td>
</tr>
<tr>
<td>H$_7$: Final grade is positively correlated with the deep and strategic approaches to learning.</td>
<td></td>
</tr>
<tr>
<td>Post Study Interviews</td>
<td>Interview responses transcribed, summarized and grouped by the most frequently occurring responses.</td>
</tr>
</tbody>
</table>

Table 4

Summary of Procedures for Data Analysis of Research Hypotheses
H$_2$: Sharing maps is positively correlated with reviewing maps and with a deep and strategic approach to learning.

The Sharing Maps scale item was analyzed with the Reviewing Maps index and the Deep Learning and Strategic Learning indices using means comparisons and correlation analyses.

H$_3$: Reviewing maps is positively correlated with the deep and strategic approaches to learning.

The Reviewing Maps index was analyzed with the Deep Learning and Strategic Learning indices using means comparisons and correlation analyses.

H$_4$: Students’ maps will become increasingly more complex over the semester.

A Friedman test was used to measure each student’s set of four concept map complexity scores over time. A repeated measures analysis was run to test for interaction effects by learner type.

H$_5$: Growth in the complexity of students’ maps will increase over the semester and will accompany periods of both assimilation and accommodation.

A Friedman test was used to measure each students’ set of four percentage of total complexity scores over time to assess growth in map complexity. A repeated measures analysis was run to test for interaction effects by learner type.

---

53 The Friedman test is a nonparametric equivalent of a repeated measures analysis.
Using the Pearsall et al. (1997) dichotomous scoring method, a zero or one was recorded for an assimilation and/or an accommodation event. A zero was recorded for no instances of an event and a one was recorded for one or more instances. A simple frequency analysis of instances of both assimilation and accommodation was run for each students’ set of concept maps.

H6: Computer use/experience is positively correlated with students’ self efficacy with computers.

The Computer / Use index was analyzed with the Self Efficacy with Computers using means comparisons and correlation analyses.

H7: Final grade is positively correlated with the deep and strategic approaches to learning.

Final Grade was analyzed with the Deep Learning and Strategic Learning indices using means comparisons and correlation analyses.

Procedures for Data Analyses of Post Study Interviews

Interview responses were transcribed from the digital audio recordings and written notes. The transcriptions were summarized and grouped by the most frequently occurring responses.
Summary of Methods

This chapter described the methods used in this study that explored the role of concept mapping as a conduit for social construction of understandings in a nontraditional online learning environment. The chapter discussed the research context of the nontraditional pharmacy online learning program, a demographic profile of the subjects and the roles of the researcher and the teacher. It then presented the study’s two research questions and seven research hypotheses. Each study construct was individually defined, operationalized and measured with appropriate references linking their theoretical foundations to the review of literature. The procedures used to collect data on each of the constructs were provided along with the instructions on how to concept map. The chapter concluded with the procedures for data analysis including procedures used to construct and define the learner types as well as procedures for analysis of the research hypotheses and post study interview data. Chapter four presents the results obtained with these methods.
CHAPTER 4: RESULTS

This study examined how nontraditional students, of varying learner types, could update their understandings in a collaborative online learning environment vis-à-vis concept mapping. This chapter presents the results obtained from this study and is organized by five major sections. First, the reliability of the measuring instruments is reported. Second, the learner type results section presents the results of grouping the nontraditional pharmacy students into learner types based on their earning and technology experiences. A description of the learner type factor loadings, definitions of the learner types based on different and shared study constructs, and an analysis of the learner types based on their collaborative behavior and academic performance is reported. Third, results for the seven research hypotheses are presented and are organized by map complexity, conceptual change, collaborative learning, technology experiences and final grade results. Fourth, PharmD students’ 110 concept maps and narrated movies of their concept mapping processes are presented. The chapter concludes with a description of the post study interview results.
Reliability of Measuring Instruments

This section reports the reliability on the measuring instruments used in this study.

Inter-Coder Reliability of the Concept Map Scoring Instrument

Three coders scored one concept map from each of the 26 pharmacy students to assess the inter-coder reliability of the concept map scoring instrument. This produced an intraclass correlation of .99 with 99% confidence and was significant on 130 cases\(^{54}\) across three coders. Cronbach’s alpha was used to test the reliability of all measuring instruments. See Table 5 for a summary of the reliability scores for the measuring instruments used in this study.

The results for type and rate of conceptual change were calculations based on students’ concept map complexity scores. As such, the high inter-coder reliability of the concept map scoring instrument was deemed important for all three constructs. Note the researcher did not have the other two coders score for type of conceptual change once it was discovered that all learners had instances of both assimilation and accommodation on all four of their concept maps. There was no reliability measure for rate of conceptual change as this construct was a statistical computation derived from students’ four concept map complexity scores.

\(^{54}\) There were five scores (concepts, conceptual relations, levels of hierarchy, instances of branching and cross-links) for each of the 26 concept maps.
Measuring Instrument | Reliability (α)
--- | ---
Inter-Coder Reliability on Map Scoring | .99
Reviewing Maps | .82
Reviewed from Whom | .82
Deep Learning | .85
Strategic Learning | .83
Surface Learning | .65
Learning as Transforming | .51
Learning as Reproducing | .22
Encouraging Understanding | .81
Transmitting Information | .04
Self Efficacy with Computers | .91
Use/Experience | .63

Table 5
Summary of Reliability of Measuring Instruments

Index Reliability

The two collaborative learning indices, reviewing maps (.82) and reviewed from whom (.82), both had acceptable reliability. Four of the seven ASSIST indices, deep learning (.85), strategic learning (.83), surface learning (.65), and encouraging understanding (.81), had acceptable reliability. The three ASSIST indices with unacceptable reliability are discussed under the next sub-heading. The two technology experience indices, self efficacy with computers (.91) and use/experience (.63), also had acceptable reliability.

55 Note the Sharing Maps construct was represented by a single scale item.
56 The deep learning and strategic learning indices had better reliability than indicated in previous research (Entwistle et al., 2000).
Removal of ASSIST Indices

Three of the ASSIST indices were removed from the defining learner types apriori formula due to their low reliability scores. The following indices were removed from this study: learning as transforming (.51), learning as reproducing (.22) and transmitting information (.04). Research hypotheses containing these constructs were not tested. The encouraging understanding index, however, was left in the learner types formula because it had an acceptable index reliability (.81) and was conceptually related to deep learning.

Learner Type Results

This section presents the results of grouping the nontraditional students into learner types based on their approaches to learning and conceptions of learning, self efficacy with using computers, and computer use/experience. First, the factor loadings for the learner types are reported. Second, the first research question is answered with a classification of the learner types and a description of the constructs on which the learner types differed and those that they shared. Third, the second research question is addressed with an analysis of the relationship between and among learner types, their collaborative behavior and their academic performance.
Learner Type Factor Loadings

The Q-mode factor analysis yielded a two-factor solution. Seventy seven percent of the variance was explained by factor one and 11 percent of the variance was explained by factor two. Twenty one pharmacy students had their primary load on factor one (see Table 6). Twenty two students had greater than a .10 differential between their two factor loadings. Students with a factor loading differential of less than .10 could have been dropped from these analyses, but were kept due to the low N. Pharmacy students with split factor loadings were clustered into a learner type based on their primary factor loading.
<table>
<thead>
<tr>
<th>Student</th>
<th>Factor Loadings(^57)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Technology Experts</td>
</tr>
<tr>
<td>1</td>
<td>.99</td>
</tr>
<tr>
<td>2</td>
<td>.98</td>
</tr>
<tr>
<td>3</td>
<td>.98</td>
</tr>
<tr>
<td>4</td>
<td>.98</td>
</tr>
<tr>
<td>5</td>
<td>.97</td>
</tr>
<tr>
<td>6</td>
<td>.95</td>
</tr>
<tr>
<td>7</td>
<td>.94</td>
</tr>
<tr>
<td>8</td>
<td>.92</td>
</tr>
<tr>
<td>9</td>
<td>.92</td>
</tr>
<tr>
<td>10</td>
<td>.90</td>
</tr>
<tr>
<td>11</td>
<td>.85</td>
</tr>
<tr>
<td>12</td>
<td>.84</td>
</tr>
<tr>
<td>13</td>
<td>.79</td>
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<tr>
<td>14</td>
<td>.78</td>
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<td>15</td>
<td>.77</td>
</tr>
<tr>
<td>16</td>
<td>.76</td>
</tr>
<tr>
<td>17</td>
<td>.73</td>
</tr>
<tr>
<td>18</td>
<td>.72</td>
</tr>
<tr>
<td>19</td>
<td>.69</td>
</tr>
<tr>
<td>20</td>
<td>.67</td>
</tr>
<tr>
<td>21</td>
<td>.58</td>
</tr>
<tr>
<td>22</td>
<td>.05</td>
</tr>
<tr>
<td>23</td>
<td>.24</td>
</tr>
<tr>
<td>24</td>
<td>.48</td>
</tr>
<tr>
<td>25</td>
<td>.67</td>
</tr>
<tr>
<td>26</td>
<td>.03</td>
</tr>
</tbody>
</table>

Table 6

Learner Type Factor Loadings

\(^{57}\) Note Technology Experts (eigenvalue = 20.12) accounted for 77.39 percent of the explained variance. Deep Strategics (eigenvalue = 2.83) accounted for 10.89 percent of the explained variance.
Learner Type Descriptions

This analysis sought to answer the first research question: *How can online nontraditional students be represented as learner types based on their approaches to learning and conceptions of learning, self efficacy with using computers, and computer use/experience?*

A means analysis was run to describe on what apriori learning and teaching experiences pharmacy students brought with them to the course. Note that these items were scored using a seven-point Likert-type scale where seven (strongly agree) was high and one (strongly disagree) was low. For example, a mean of 6.50 indicated the learner type “strongly agreed” with the scale item.

**Learner Type One: Technology Experts**

This section discusses the constructs that differentiated learner type one from learner type two with these comparisons. The learner types are differentiated on the learning and technology experiences scale items each group rated highest, the items they agreed with, and the items each group rated lowest. In this manner, a picture of their characteristics can be more clearly seen. Table 7 indicates the highest rated learning and technology experiences scale items on which the learner types differed. Table 8 presents the middle rated learning and technology experiences scale items on which the learner types differed.

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58 Note that the data in the following learner type tables are mean scores of the scale items by learner type. While some of the different high, middle, and low rated scale items were significantly differently, they were not noted for two reasons. First, the researcher did not want to overstate the results of the study. Second, the rationale for defining the learner types was based on items on which they differed and items which they shared. In short, this analysis was designed to show the dominant characteristics of each learner type rather than statistically significant differences among scale items.
<table>
<thead>
<tr>
<th>Index</th>
<th>Scale Item</th>
<th>Technology Experts</th>
<th>Deep Strategics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self Efficacy</td>
<td>I am confident in my ability to use my computer</td>
<td>6.14</td>
<td>5.60</td>
</tr>
<tr>
<td>Deep Learning</td>
<td>I examine details carefully to see how they fit in</td>
<td>5.19</td>
<td>6.20</td>
</tr>
<tr>
<td></td>
<td>I understand the meaning of what we have to learn</td>
<td>5.48</td>
<td>6.60</td>
</tr>
<tr>
<td></td>
<td>I stop to reflect on what I am trying to learn</td>
<td>5.19</td>
<td>6.00</td>
</tr>
<tr>
<td>Encourages Understanding (Deep)</td>
<td>Professors who encourage us to think for ourselves</td>
<td>5.95</td>
<td>6.80</td>
</tr>
<tr>
<td></td>
<td>Exams that let me show I’ve thought about the course</td>
<td>5.76</td>
<td>6.40</td>
</tr>
<tr>
<td></td>
<td>Books that challenge you and provide explanations</td>
<td>5.52</td>
<td>6.40</td>
</tr>
<tr>
<td>Strategic Learning</td>
<td>I manage to find conditions for studying</td>
<td>5.57</td>
<td>6.60</td>
</tr>
<tr>
<td></td>
<td>I go over the work I’ve done to check the reasoning</td>
<td>5.38</td>
<td>6.40</td>
</tr>
<tr>
<td></td>
<td>I organize my study time carefully</td>
<td>5.14</td>
<td>6.20</td>
</tr>
<tr>
<td></td>
<td>It’s important for me to feel I’m doing well</td>
<td>6.19</td>
<td>7.00</td>
</tr>
</tbody>
</table>

Table 7

Highest Rated Learning and Technology Experiences Scale Items on which the Learner Types Differ

---

Note: The learner type with a higher (i.e., strongly agree) mean score is bolded.
<table>
<thead>
<tr>
<th>Index</th>
<th>Scale Item</th>
<th>Technology Experts</th>
<th>Deep Strategics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self Efficacy</td>
<td>Learning to use new services through the Internet is easy</td>
<td>5.48</td>
<td>4.20</td>
</tr>
<tr>
<td>Use/Experience</td>
<td>Years you have owned a personal computer?</td>
<td>7.90</td>
<td>2.90</td>
</tr>
<tr>
<td></td>
<td>Months you have had Internet at home?</td>
<td>57.20</td>
<td>22.80</td>
</tr>
<tr>
<td></td>
<td>Hours/week you spend working on your computer?</td>
<td>20.90</td>
<td>44.00</td>
</tr>
<tr>
<td>Deep Learning</td>
<td>I find myself questioning things I hear in lectures</td>
<td>4.09</td>
<td>5.20</td>
</tr>
<tr>
<td></td>
<td>Ideas in articles set me off on long chains of thought</td>
<td>4.14</td>
<td>5.40</td>
</tr>
<tr>
<td>Encourages Understanding (Deep)</td>
<td>Courses where we’re encouraged to read around the subject</td>
<td>3.81</td>
<td>5.00</td>
</tr>
<tr>
<td>Strategic Learning</td>
<td>I keep in mind who is going to grade an assignment</td>
<td>3.38</td>
<td>5.20</td>
</tr>
<tr>
<td></td>
<td>I’m good at following up on professors’ suggestions</td>
<td>4.14</td>
<td>5.40</td>
</tr>
</tbody>
</table>

Table 8

Middle Rated Learning and Technology Experiences Scale Items on which the Learner Types Differ\(^{60}\)

---

\(^{60}\) Note the learner type with a higher (i.e., agree) mean score is bolded.
Learner type one is characterized by high self efficacy with using computers and high computer use and experience. Students in this learner type are labeled “Technology Experts.” Technology Experts perceived themselves as being more efficacious with using computers. They scored higher on the ability to use computers in the NTPD program (6.14 vs. 5.60) and on learning to use new Internet services (5.48 vs. 4.20). Technology Experts also had more overall experience with using computers and the Internet. They had higher mean scores on years they have owned a personal computer (7.90 vs. 2.90) and how many months they have had home Internet access (57.20 vs. 22.80).

Technology Experts had lower mean scores on negative self efficacy with computers scale items. Table 9 presents the lowest rated learning and technology experiences scale items on which the learner types differed. These items included: being afraid of computers (2.33 vs. 3.80), difficulty in learning new software (2.90 vs. 4.20), feeling incompetent when using computers (2.33 vs. 3.60), and having difficulty getting new software to work (2.71 vs. 4.00). Technology Experts reported they were less likely to concentrate on memorize information (2.71 vs. 4.40). They were also less likely to lie awake worrying about their work (2.52 vs. 4.20).
<table>
<thead>
<tr>
<th>Index</th>
<th>Scale Item</th>
<th>Technology Experts</th>
<th>Deep Strategics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self Efficacy</td>
<td>I am afraid of computers</td>
<td>2.33</td>
<td>3.80</td>
</tr>
<tr>
<td></td>
<td>I often have difficulty getting new software to work</td>
<td>2.90</td>
<td>4.20</td>
</tr>
<tr>
<td></td>
<td>I feel incompetent when I try to use a computer</td>
<td>2.33</td>
<td>3.60</td>
</tr>
<tr>
<td></td>
<td>Learning new computer software programs is difficult</td>
<td>2.71</td>
<td>4.00</td>
</tr>
<tr>
<td>Strategic Learning</td>
<td>I keep in mind how best to impress the professor</td>
<td>3.05</td>
<td>5.20</td>
</tr>
<tr>
<td>Surface Learning</td>
<td>I have to concentrate on memorizing what I have to learn</td>
<td>2.71</td>
<td>4.40</td>
</tr>
<tr>
<td></td>
<td>Often I lie awake worrying about work</td>
<td>2.52</td>
<td>4.20</td>
</tr>
<tr>
<td></td>
<td>I concentrate on learning the information I need to pass</td>
<td>2.19</td>
<td>1.40</td>
</tr>
</tbody>
</table>

Table 9

Lowest Rated Learning and Technology Experiences Scale Items on which the Learner Types Differ

Note the learner type with a lower (i.e., strongly disagree) mean score is bolded.
Learner Type Two: Deep Strategics

This section discusses the constructs that differentiated learner type two from learner type one. Learner type two is characterized by a deep, strategic approach to learning. Students in this learner type are labeled “Deep Strategics.”

Deep Strategics scored higher on deep learning scale items (see Tables 7 and 8) including: examining details carefully (6.20 vs. 5.19), understanding the meaning of what they have to learn (6.60 vs. 5.48), reflecting on their learning (6.00 vs. 5.19), questioning what they heard in lectures (5.20 vs. 4.09) and to thinking deeply about new ideas (5.40 vs. 4.14). They also had a strong preference for courses and teachers that encouraged their understanding of new ideas. They had stronger preferences for: professors who encouraged them to think for themselves (6.80 vs. 5.95), exams that let them show what they understood (6.40 vs. 5.76), challenging books (6.40 vs. 5.52) and for courses in which they were encouraged to read (5.00 vs. 3.81).

Deep Strategics scored higher on strategic learning scale items (see Tables 7 and 8) including: finding good conditions to study (6.60 vs. 5.57), checking the reasoning of their work (6.40 vs. 5.38), organizing their study time (6.20 vs. 5.14), it was important they felt good about their work (7.00 vs. 6.19), considering who will grade their assignment (5.20 vs. 3.38), utilizing professors’ suggestions (5.40 vs. 4.14), and knowing how to best impress their professors (5.20 vs. 3.05).
Deep Strategics also had a higher mean score on their average weekly hours of computer use (44.00 vs. 20.90) (see Table 8). They also reported they were less likely to concentrate on learning only the information they needed to know to pass a course (1.40 vs. 2.19) (see Table 9).

Constructs the Learner Types Shared

This section discusses the constructs that both learner types shared. Table 10 presents the learning and technology experiences scale items the learner types shared. The two learner types shared four self efficacy scale items. Both learner types reported they got frustrated and felt out of control when they could not get their computers to work well (5.38 vs. 5.60). Both learner types also felt relatively confident in their ability to either fix computer problems or to find an external resource to help them (5.38 vs. 5.60). Neither learner type reported avoiding computers as much as possible (2.10 vs. 2.60), nor did they worry that their academic performance in the NTPD program was hurt because of computer problems (2.14 vs. 2.60).

Technology Experts and Deep Strategics shared two Use/Experience scale items. Both learner types had used computers in the workplace (11.50 vs. 10.70) and for educational purposes (5.80 vs. 5.40) for approximately the same number of years.
<table>
<thead>
<tr>
<th>Index</th>
<th>Scale Item</th>
<th>Technology Experts</th>
<th>Deep Strategics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep Learning (High)</td>
<td>I sometimes get ‘hooked’ on academic topics</td>
<td>5.52</td>
<td>6.20</td>
</tr>
<tr>
<td></td>
<td>I try to find out exactly what the author means</td>
<td>5.67</td>
<td>6.20</td>
</tr>
<tr>
<td></td>
<td>I try to relate ideas to those in other topics</td>
<td>6.05</td>
<td>5.60</td>
</tr>
<tr>
<td></td>
<td>Some ideas I find really gripping</td>
<td>5.86</td>
<td>6.20</td>
</tr>
<tr>
<td></td>
<td>Important for me to follow the argument</td>
<td>6.09</td>
<td>6.40</td>
</tr>
<tr>
<td></td>
<td>I try to see how all the ideas fit together</td>
<td>6.14</td>
<td>6.40</td>
</tr>
<tr>
<td></td>
<td>Studying academic topics can be exciting</td>
<td>6.09</td>
<td>6.00</td>
</tr>
<tr>
<td>Strategic Learning (High)</td>
<td>Good progress helps me put in more effort</td>
<td>6.00</td>
<td>6.40</td>
</tr>
<tr>
<td></td>
<td>I think about what I want out of this course</td>
<td>5.76</td>
<td>6.40</td>
</tr>
<tr>
<td></td>
<td>I make good use of my time during the day</td>
<td>5.24</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>I put a lot of effort into studying</td>
<td>5.90</td>
<td>6.40</td>
</tr>
<tr>
<td></td>
<td>I think how best to tackle an assignment</td>
<td>5.67</td>
<td>6.20</td>
</tr>
<tr>
<td></td>
<td>I plan out my week’s work in advance</td>
<td>5.38</td>
<td>6.20</td>
</tr>
<tr>
<td></td>
<td>I check my work against the requirements</td>
<td>6.05</td>
<td>6.40</td>
</tr>
<tr>
<td></td>
<td>I’m pretty good at getting down to work</td>
<td>6.05</td>
<td>6.20</td>
</tr>
<tr>
<td>Surface Learning (High)</td>
<td>I like to be told precisely what to do</td>
<td>5.71</td>
<td>6.40</td>
</tr>
<tr>
<td>Self Efficacy (Middle)</td>
<td>I am confident in my ability to fix my computer</td>
<td>3.67</td>
<td>3.40</td>
</tr>
<tr>
<td></td>
<td>I feel out of control when my computer won’t work</td>
<td>5.38</td>
<td>5.60</td>
</tr>
<tr>
<td>Use/Experience</td>
<td>Years you have used computers at work?</td>
<td>11.52</td>
<td>10.72</td>
</tr>
<tr>
<td></td>
<td>Years you have used computers for your education?</td>
<td>5.82</td>
<td>5.40</td>
</tr>
</tbody>
</table>

Table 10 (Continued)

Learning and Technology Experience Scale Items the Learner Types Shared
Table 10: Continued

<table>
<thead>
<tr>
<th>Index</th>
<th>Scale Item</th>
<th>Technology Experts</th>
<th>Deep Strategics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep Learning (Middle)</td>
<td>I like to play around with ideas of my own</td>
<td>4.81</td>
<td>4.60</td>
</tr>
<tr>
<td></td>
<td>I’m organized in reviewing for exams</td>
<td>4.90</td>
<td>5.20</td>
</tr>
<tr>
<td></td>
<td>I don’t find it at all difficult to motivate myself</td>
<td>5.57</td>
<td>5.60</td>
</tr>
<tr>
<td>Strategic (Middle)</td>
<td>I’m not really sure what’s important in lectures</td>
<td>3.81</td>
<td>3.40</td>
</tr>
<tr>
<td></td>
<td>I often panic if I get behind with my work</td>
<td>4.67</td>
<td>4.40</td>
</tr>
<tr>
<td></td>
<td>I study what seems to be required</td>
<td>4.05</td>
<td>4.20</td>
</tr>
<tr>
<td>Surface (Middle)</td>
<td>I avoid computers as much as possible</td>
<td>2.10</td>
<td>2.60</td>
</tr>
<tr>
<td></td>
<td>My grades suffer because of computer problems</td>
<td>2.14</td>
<td>2.60</td>
</tr>
<tr>
<td>Self Efficacy (Low)</td>
<td>I’m not really interested in this course</td>
<td>1.17</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td>I wonder if the work I am doing here is worthwhile</td>
<td>2.67</td>
<td>1.80</td>
</tr>
<tr>
<td></td>
<td>I wonder why I ever decided to come here</td>
<td>2.29</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>I have trouble in making sense of the things</td>
<td>2.52</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>I don’t find my course interesting or relevant</td>
<td>1.33</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td>Much of what I’m studying makes little sense</td>
<td>1.52</td>
<td>1.40</td>
</tr>
<tr>
<td></td>
<td>I read little beyond what is actually required</td>
<td>3.14</td>
<td>2.80</td>
</tr>
</tbody>
</table>
Both learner types shared eight deep learning scale items including: getting hooked on academic topics (5.52 vs. 6.20), finding out the author’s meaning (5.67 vs. 6.20), relating ideas to other topics (6.05 vs. 5.60), finding some ideas gripping (5.86 vs. 6.20), it was important to follow an argument (6.09 vs. 6.40), to see how ideas fit together (6.14 vs. 6.40), studying academic topics was exciting (6.09 vs. 6.00), and playing around with one’s own ideas (4.81 vs. 4.60).

Both learner types also shared ten strategic learning scale items including: good progress was linked to effort (6.00 vs. 6.40), they think about what they want out of a course (5.76 vs. 6.40), make good use of their time (5.24 vs. 6.00), put effort into studying (5.90 vs. 6.40), think about how to best approach an assignment (5.67 vs. 6.20), planning a week’s work in advance (5.38 vs. 6.20), checking their work against the requirements (6.05 vs. 6.40), good at getting to work (6.05 vs. 6.20), organized in reviewing for exams (4.90 vs. 5.20), and they did not find it difficult to motivate themselves (5.57 vs. 5.60).

While neither learner type was characterized as surface students, both learner types shared multiple surface learning scale items. Both learner types strongly agreed they liked to be told precisely what to do (5.71 vs. 6.40). They agreed they: were not sure what was important in lectures (3.81 vs. 3.40), panic if they get behind in their work (4.67 vs. 4.40) and only study what is required (4.05 vs. 4.20). Both learner types, however, strongly disagreed that they: were not interested in the course (1.17 vs. 1.20), wondered if their program was worth while (2.67 vs. 1.80) or

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62 Deep Strategics had higher mean scores on five of the eight deep scale items.
63 Deep Strategics had higher mean scores on all ten of the shared strategic scale items.
why they decided to start the program (2.29 vs. 1.60), had trouble making sense of things (2.52 vs. 2.00), found the course irrelevant (1.33 vs. 1.20), found course materials made little sense (1.52 vs. 1.40) or that they read only what was required (3.14 vs. 2.80).

**Learner Type Analyses**

After placing the PharmD students in learner types, this study attempted to answer the second research question: *What are the relationships between and among learner types, their collaborative behavior and their academic performance?* Pharmacy students’ collaborative behavior was operationalized as how many times students shared their concept maps and how many times they reviewed others’ concept maps. Their academic performance was determined by the complexity of their concept maps (representing their conceptual frameworks), increased by frequency of mapping, and their final grade. The results of these analyses are displayed in Table 11.
There were no significant differences between learner types on complexity of students’ concept maps, frequency of mapping or on final grade. That these doctoral students all earned exceptional grades is no surprise, but it was interesting the learner types did not significantly differ on map complexity or frequency of mapping. Based on these findings, the apriori learning and technology experiences students brought with them to the learning environment had little or no effect on their ability or willingness to map their understandings.

Note the data in Table 11 are the means of map complexity, sharing maps, reviewing maps, frequency of mapping and final grade by learner type.
There were, however, significant differences between Deep Strategics (3.75) and Technology Experts (.38) on sharing maps. There were also significant differences between Deep Strategics (38.25) and Technology Experts (14.24) on reviewing maps. These results indicated Deep Strategics collaborated with their concept maps more than Technology Experts, and more important, the learning and technology experiences students brought with them to the learning environment did have an effect on their ability or willingness to share their understandings.

Research Hypotheses Results

While knowing how learner types differed on some of the study constructs was helpful to comprehend how the learner types constructed and shared their understandings, this study also wanted to realize how the constructs correlated with one another. Identifying how these constructs relate to one another may help teachers design online learning environments for nontraditional learners. This section describes the results of the correlation analyses between study constructs as well as related responses from the pre and post surveys (see Appendix D) and the post study interviews (see Appendix C).

Concept Map Complexity Results

Complexity was a central construct in these hypotheses analyses. Pharmacy students’ sophistication of understanding was equated with high concept map complexity, and complexity changes across students’ concept maps over time represented students’ rate and type of conceptual change. The complexity of students’ concept maps was hypothesized to be positively correlated with
collaborative learning, deep and strategic approaches to learning, technology experiences, frequency of mapping and by final grade. The results of these analyses are presented in Table 12.

The complexity of pharmacy students’ concept maps was moderately correlated with their frequency of mapping (.62). That is, students who came back to their existing concept maps and made changes to them frequently had higher total concept map complexity scores. This finding was important because sharing understandings in an online learning environment takes repetition and experience to become comfortable with the concept map tool and to learn how to share one’s understandings with other students. Complexity, however, was not significantly correlated with: sharing maps, reviewing maps, self efficacy, use/experience, deep learning, strategic learning, surface learning and/or final grade.

It is important to restate that complexity of concept maps was assumed to represent students’ conceptual understandings. Based on that assumption and these findings, students understandings were affected by how often they revisited and made changes to their understandings. Their understandings, however, were not affected by their collaborative learning activities, their approach to learning, their technology experiences, or by their final grade. These results, in short, ran counterintuitive to this study’s core assumptions. A possible explanation for these results will be explored in chapter five.
<table>
<thead>
<tr>
<th></th>
<th>Map Complexity</th>
<th>Sharing Maps</th>
<th>Reviewing Maps</th>
<th>Frequency of Mapping</th>
<th>Self Efficacy</th>
<th>Use/Experience</th>
<th>Deep Learning</th>
<th>Strategic Learning</th>
<th>Surface Learning</th>
<th>Final Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharing Maps</td>
<td>.25&lt;sup&gt;65&lt;/sup&gt; (.11)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reviewing Maps</td>
<td>.16 (.23)</td>
<td>.64* (.00)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of Mapping</td>
<td>.62* (.00)</td>
<td>.31 (.14)</td>
<td>.19 (.37)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self Efficacy</td>
<td>.22 (.15)</td>
<td>- .37 (.07)</td>
<td>- .37 (.07)</td>
<td>.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use/Experience</td>
<td>- .04 (.43)</td>
<td>-.44* (.03)</td>
<td>-.62* (.00)</td>
<td>.05</td>
<td>.51* (.01)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep Learning</td>
<td>.14 (.25)</td>
<td>.45* (.01)</td>
<td>.27 (.10)</td>
<td>-.08</td>
<td>.08 (.72)</td>
<td>-.38 (.06)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strategic Learning</td>
<td>.16 (.23)</td>
<td>.24 (.13)</td>
<td>.13 (.27)</td>
<td>-.28</td>
<td>.09 (.68)</td>
<td>-.19 (.36)</td>
<td>.57* (.00)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Learning</td>
<td>-.11 (.31)</td>
<td>.08 (.35)</td>
<td>.26 (.10)</td>
<td>-.02</td>
<td>-.25 (.22)</td>
<td>.15 (.47)</td>
<td>-.22 (.14)</td>
<td>-.22 (.14)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Grade</td>
<td>.15 (.24)</td>
<td>-.17 (.43)</td>
<td>.09 (.67)</td>
<td>.04</td>
<td>.20 (.34)</td>
<td>-.12 (.56)</td>
<td>-.06 (.38)</td>
<td>-.06 (.40)</td>
<td>-.17 (.21)</td>
<td></td>
</tr>
</tbody>
</table>

Table 12

Correlation Matrix of Research Hypotheses Constructs Including: Map Complexity, Sharing Maps, Reviewing Maps, Frequency of Mapping, Self Efficacy, Use/Experience, Deep, Strategic, and Surface Learning and Final Grade

<sup>65</sup> Note the data in Table 12 are the bivariate correlations with the p-value below in parentheses. * Significant.
Conceptual Change Results

This section presents the results for the fourth and fifth research hypotheses:

$H_4$: *Students’ maps will become increasingly more complex over the semester, and* 

$H_5$: *Growth in the complexity of students’ maps will increase over the semester and will accompany periods of both assimilation and accommodation.*

Type of Conceptual Change Results

In addition to measuring PharmD students’ conceptual understandings as represented by the complexity of their concept maps, this study wanted to understand the type (i.e., assimilation vs. accommodation) of students’ conceptual changes as they learned and made changes to their understandings throughout Pathophysiology and Therapeutics III. All pharmacy students’ concept map complexity scores increased over time and all 25 students had instances of both assimilation and accommodation on all four of their concept maps. A Friedman test on students’ four concept map complexity scores over time was significant at <.01 (Chi-square = 75, df = 3).

**Assimilation results.** Click on this [audio link] to hear four students discuss how and why they *assimilated* new understandings into their concept maps. The first pharmacy student said “My approach was to start slow and add as I learned more. I did not create a powerhouse right from the beginning… so I did not have to delete or pare down.” The second PharmD student concurred with “No, I don’t think I removed any links. I think… I increased links as I learned more.”
The third pharmacist suggested she “pretty much kept everything I had and tried to keep a pretty baseline web there and then add details at the end.” And the fourth student succinctly stated “I would add, but not delete or change.”

Accommodation results. Click on this audio link to hear two students organizational reasons for making accommodation type changes to remove the “clutter” from their concept maps. The first student reported “If the map got too big… I might have deleted the intricate details… but that didn’t have to do with understanding. That had to do with clutter.” The second student repeated this “clutter removal” theme with “when the areas got too cluttered and I couldn’t spread them out as much as I wanted to, I did eliminate things that I thought were more basic.” Similarly, three PharmD students discussed how concept mapping helped them to organize their thoughts. Students’ written responses from the post survey echoed how they used concept maps to organize their understandings: “the material seemed to be more solidified in my brain by doing this… I remember things much better when I write things down,” “I think [concept mapping] can be a useful brainstorming tool,” and “I would like to review all my maps at the end of this course and save them so that I can use as a reference in the future.”

See Figures 17 and 18 to view slices of a pharmacy student’s second and third concept maps to view both types of conceptual change as she made changes to her concept maps. Click on this link to view her entire second concept map. Click on this link to view her entire third concept map.

Note the researcher modified these two concept map slices so the pertinent sections of the maps could be viewed in this printed document. For a full, unaltered view of this student’s two concept maps, click on the appropriate links above.
Figure 17. Slice of student’s second concept map to show assimilation and accommodation conceptual changes.
Figure 18. Slice of student’s third concept map to show assimilation and accommodation conceptual changes.
The student’s second map is primarily focused on developing her understandings of Parkinson’s disease. For example, her map can be read from top to bottom as a sentence: “Pathophysiology III is the study of Parkinson’s disease and its signs and symptoms initially include aching pain, oldness, stiffness, numbness and parenthesis.” The student’s third map further refined her understandings of Parkinson’s disease and added Schizophrenia to her conceptual framework.

By comparing her two concept maps in sequence, instances of both assimilation and accommodation can be seen. For example, instances of assimilation included the addition of “also Lewy Bodies = patho-finding” under the “Parkinson / Pathogenesis” branch, and the addition of multiple schizophrenia concepts. Instances of accommodation included removing the “Pathology” and “Etiology” concepts from the third level of hierarchy under the Parkinson’s hierarchy. The addition of “Schizophrenia” and the “Epidemiology, Pathophysiology,” and “Clinical Presentations” concepts (as third levels of hierarchy under Schizophrenia) were also examples of accommodation. A reader of these two maps might conclude that this student both changed her understandings of Parkinson’s disease and learned something new about Schizophrenia between the construction of her second and third concept maps.
Rate of Conceptual Change Results

Rate of conceptual change described when, in the course of the study, students engaged in major additions to their conceptual understandings as represented as changes in the complexity of their concept maps. While informative to this study’s findings, these data will be used in a larger research project of which this study was a section. While pharmacy students’ concept maps increased in complexity over time, the percentage of their total concept map complexity score constructed during each of the four mapping intervals (second mapping date, third date, and fourth date) decreased over time as shown in Figure 19.
A Friedman test on students’ four percentages of total concept map complexity as recorded during each mapping interval, was not significant. On average, pharmacy students constructed higher percentages of their total complexity map score while building maps one and two. That percentage dropped rapidly when they built maps three and four. For example, one student constructed 36 percent of her total complexity score in her first concept map. The percentage of her total map complexity score constructed in each mapping interval decreased as she constructed
her second (29 percent), third (20 percent), and fourth (15 percent) concept maps (click on these links to view the student’s four concept maps). This finding is further supported by the post study interview results in which 12 students reported they spent the most time on their first concept map.

**Collaborative Learning Results**

This section presents the results for the second and third research hypotheses: 

\[ H_2: \text{Sharing maps is positively correlated with reviewing maps and with a deep and strategic approach to learning, and } H_3: \text{Reviewing maps is positively correlated with the deep and strategic approaches to learning}. \]

One of the goals of this study was to develop an understanding of how online learning environments could be designed to better suit the learning problems and authentic learning needs of nontraditional students. One proposed solution, social construction of understandings, required students collaborate with one another to share what they know. These results, as presented in Table 12, describe how often students collaboratively shared their maps and reviewed others’ maps and reported how these collaborative activities were related to deep and strategic approaches to learning.

Sharing maps was moderately correlated with reviewing maps (.64) and with deep learning (.45). Sharing maps was, however, not significantly correlated with strategic learning. Reviewing maps was not significantly correlated with deep learning or strategic learning.
Note that students with a deep approach to learning were more likely to share their concept maps. Though sharing maps and reviewing maps were moderately correlated, students elected not to engage in collaborative sharing of their concept maps.

Low Collaboration

A majority of PharmD students did not actively share their concept maps or review others’ maps. Eighteen pharmacy students did not ask anyone in their group to review their maps and twenty two students did not ask anyone outside of their group to review their maps. The class mean for the number of times students encouraged others to review their maps was less than one. Twenty three students did not ask their teachers to review their maps. Only two students directly gave a copy of their concept map(s) (as a "gif" file or as a paper printout) to another student.

Limited to students’ work groups. What limited collaboration that did occur was limited primarily to students’ work groups. Pharmacy students were more likely to ask students in their group (.90) than students outside their group (.28) to review their maps, and were least likely to ask their teachers (.12). In the post survey responses, students provided multiple reasons for why they most often asked students within their group to review their concept maps including: “I know them better than any other group,” “[I] do not know students outside of our groups very well, [we are] not a close community,” and “I asked my group members to review it because it was convenient to communicate with them during OHL [synchronous communication tool],” and “[I] would only ask someone I knew well and respected
in my group.” One student’s comment summarized the general feeling of the class: “I was more likely to ask the members of my group with whom I work closely with on a regular basis.” To help triangulate these data, students were asked the same question again in the post study interviews. PharmD students’ responses confirmed that most students did not ask others to review their maps, and the few who did, asked members of their own group. One student suggested she “will not pester someone unless I need help” indicating a sensitivity to others’ time constraints.

Technology Experiences Results

This section presents the results for the sixth research hypothesis: $H_6$:

*Computer use/experience is positively correlated with students’ self efficacy with computers.*

Understanding the technology experiences and attitudes about technology pharmacy students brought with them to this online learning environment was important. Not only did these students have to learn how to use the new concept map tool, but they had to understand how to save their maps to both their local computer and to the public concept map server. This act alone required a fairly sophisticated understanding of directory structure and client/server network relationships. This study hypothesized that students’ experiences with using computers and their confidence in their ability to do so would be positively correlated. In fact, computer use/experience was moderately correlated with self efficacy with computers (.51).
What was not expected was computer use/experience was negatively correlated with deep learning (-.38). Even more confusing, use/experience was negatively correlated with both sharing maps (-.44) and reviewing maps (-.62) and self efficacy was negatively correlated with both sharing maps (-.37) and reviewing maps (-.37). While these relationships were not hypothesized, the study assumed students with stronger technological skills would be more able to share their concept maps and review others’ concept maps. These potentially counterintuitive findings are explored in the Discussions chapter.

Final Grade Results

This section presents the results for the seventh research hypothesis: $H_7$: 

*Final grade is positively correlated with the deep and strategic approaches to learning.*

Final grade was not significantly correlated with any of the study constructs. Through deep learning was moderately correlated with strategic learning (.57), final grade was not significantly correlated with either of the learning approach constructs. The lack of significant findings may have been due to an extremely tight grade distribution. Twenty one students earned an A, one A-, one B+, one B and one student earned a C grade. That these doctoral students all earned exceptional grades was no surprise. These students were professional, doctoral level students with bachelor degrees and, on average, over nine years experience in the pharmacy workplace. In short, they were bright, capable students who were highly motivated to do well academically.
Students’ Concept Maps Results

After clustering and defining the two learner types, the next challenge was to score students’ 110 concept maps. To help the reader understand the uniqueness and volume of data captured in this study, pharmacy students’ concept maps and narrated movies of their concept mapping processes are presented in Table 13.
<table>
<thead>
<tr>
<th>Student</th>
<th>Technology Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Movie / Map 1 / Map 2 / Map 3 / Map 4</td>
</tr>
<tr>
<td>2</td>
<td>Movie / Map 1 / Map 2 / Map 3 / Map 4</td>
</tr>
<tr>
<td>3</td>
<td>Movie / Map 1 / Map 2 / Map 3 / Map 4</td>
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**Deep Strategics**

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</tr>
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<td>22</td>
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<td>23</td>
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<td>24</td>
<td>Movie / Map 1 / Map 2 / Map 3 / Map 4 / Map 5</td>
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<td>25</td>
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</tr>
<tr>
<td>26</td>
<td>Movie / Map 1 / Map 2 / Map 3 / Map 4</td>
</tr>
</tbody>
</table>

Table 13

Students’ Concept Maps and Narrated Movies

190
In addition to full images of all 110 concept maps, samples of all students’ concept maps are layered in sequence in QuickTime® movies67. These movies fade from map to map as students narrate moments of conceptual change and collaboration with their concept maps and colleagues. Click on each PharmD students’ concept map in sequence for a graphical representation of how their understandings changed over the course of the study. For example, student 24, a Deep Strategic, constructed four separate concept maps over the course of the study. See Figure 20 for slice of her first concept map. Click on the links labeled “Map 1 / Map 2 / Map 3 / Map 4” in Table 13 to view each of her maps in their entirety.

Click on the “Movie” link on Table 13 next to student 24 to see her concept maps change over time as she describes her experiences with concept mapping. She describe how she made an organizational decisions about what categories to use under each disease state and how she kept those categories the same color on each of her separate concept maps. She also notes concept mapping helped her to organize her thoughts and her ideas in relation to each course learning module.

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67 Note that students one through 21 are Technology Experts and students 22 through 26 are Deep Strategics.
Figure 20. Slice of student 24’s first concept map.
Post Study Interview Results

The post study interviews were conducted as a post-hoc analysis after the second survey data were reviewed. The interview was constructed to triangulate quantitative findings and pursue areas of interest and anomaly. See Appendix C for the summarized text and full audio post study interview responses.

Summary of Results

The results presented in this chapter indicated first, nontraditional students could be represented as learner types based on the learning and technology experiences they brought with them to an online learning environment. Technology Experts were efficacious computer users with substantial technological experience. Deep Strategics were characterized by a deep, strategic approach to learning.

Second, there were no significant differences between learner types on the complexity of students’ concept maps, how often they mapped, or on their final grades. Deep Strategics, however, collaborated by both sharing and reviewing maps, significantly more than did Technology Experts. This finding suggested the learning approaches the pharmacy students brought with them to their learning environment might have had an effect on their ability or willingness to share their understandings vis-à-vis concept mapping.

Third, many of the results from the seven research hypotheses, the pre and post surveys and the post study interviews were not supported. While the complexity of pharmacy students’ concept maps was significantly correlated with how frequently they mapped, complexity was not significantly correlated with any
other construct. Assuming concept map complexity represented these doctoral students' knowledge bases, their understandings were not affected by their collaborative learning activities, their approaches to learning, their technology experiences, or by their final grade in Pathophysiology and Therapeutics III. The results on complexity, in short, ran counterintuitive to this study’s core assumptions.

Pharmacy students experienced both evolutionary and revolutionary conceptual changes on all four of their concept maps. More interesting, the percentage of students’ total concept map complexity score constructed during each of the four mapping intervals decreased over time.

These pharmacists’ collaborative concept mapping activities can be summed in two sentences. A majority of them did not actively share their maps or review others’ maps. What limited collaboration that did occur was limited primarily to students’ work groups.

PharmD students’ self efficacy with using computers and their experience with computers was significantly correlated. Far more interesting, however, was these students’ self efficacy with computers and their computer experience were negatively correlated with how often they shared their maps with others and how often they reviewed their colleagues’ maps. Further, their computer experience was negatively correlated with deep learning. A summary and a discussion of these potentially counterintuitive findings are presented in the next chapter.
CHAPTER 5: DISCUSSION

The purpose of this research was to explore the role of concept mapping as a tool to enable practicing pharmacists to visualize, manage and share their conceptual understandings in an online learning community. Further, the study sought to gain a deeper understanding of how to design a learning environment within which a community of mid-career students could communicate and collectively share their existing expertise and work together to understand new information. Chapter five reviews and provides a discussion of the results. The results present a snapshot of students’ behavioral responses to the rules of their learning environment. While understanding the learning conditions under which students will actively participate with new tools and pedagogies is critical to designing collaborative learning environments, these results are located within a larger theoretical construct. Understanding the interactions between students’ creative use of educational technologies, learning community processes and collaborative learning provides the conceptual rationale for future studies.
The major sections of this chapter summarize the key findings, present a proposed collaborative online learning community model for nontraditional students, and discuss the model’s theoretical and practical implications. The chapter concludes with recommendations for methods and measurement and recommendations for future research.

Summary of Key Findings

The most interesting findings are often unintentional. Fleming had been working on lysozyme, an enzyme found in tears that digests the cell walls of bacteria and helps to prevent infection. While organizing a pile of petri dishes, he noticed a culture dish containing staphylococcus had accidentally become infected with mold that kept the bacteria from growing. Fifteen years later Florey and Chain were able to extract the antibiotic penicillin. Similarly, the notable findings from this study were not found from directly examining the data, but by looking at the spaces in between.

Review of the Study

The study examined pharmacists with busy lives who wanted to stay current in their field by upgrading their understandings in an online nontraditional pharmacy degree program. The designers of this program learned early on that these pharmacy students possessed high levels of expertise based on their prior educational experience and their years of practice in the field. The program was therefore based heavily in collaborative learning pedagogy so students would have ample opportunity to learn from one another.
For example, all students were placed in work groups at the beginning of the program. These groups were then provided with multiple communication tools (e.g., e-mail, electronic whiteboard, and OfficeHoursLive®) and collaborative learning spaces (e.g., private bulletin boards and web presentation space) to facilitate collaborative learning. To further facilitate sharing of understandings, concept mapping was introduced to students in May of 2002 to enable students to explicitly visualize and share their understandings with other students in a course on pathophysiology and therapeutics.

Concept mapping was explored as a method to help learners visualize, manage, and share their conceptual understandings with other learners in their online learning community. Twenty-six pharmacy doctoral students, each belonging to one of two learner types, were provided with concept mapping software, instructions, and a public concept map server. They responded to two written surveys, constructed four concept maps over the course of a trimester, and participated in a post-study interview. The researcher asked how pharmacists’ prior learning and technology experiences affected how they used concept mapping in their collaborative online learning community.

First, pharmacy students were classified as one of two learner types, Technology Experts or Deep Strategics, based on their approaches to and conceptions of learning, preferences for teaching, and self efficacy and use/experience with computers. After clustering students into learner types, the study determined the relationships between and among learner types, their
collaborative behavior and their academic performance. Second, seven research hypotheses were proposed to better understand the relationships between the study constructs across all students. All seven hypotheses were designed to test the theory that concept mapping would enable students, of different learning types, to explicitly visualize, manage and share their understandings so all students could benefit from the distributed expertise inherent in their learning community. If evidence was found to support this theory, it might help to solve the original stated problem and help professional students update their understandings in their workplace. Some of the hypotheses results were at first unexpected and seemingly counterintuitive. The study’s interesting findings were at first found by exploring a chasm between distributed expertise and sharing understanding.

**Chasm Between Distributed Expertise and Sharing Understandings**

This project assumed adult pharmacy students would benefit from collaborating with their colleagues who possessed different understandings and skills to continually update their pharmaceutical skills and understandings. In short, a community of professionals can and should benefit from the dispersed expertise within their ranks. The researcher hypothesized that this communication of understandings required pharmacists share their concept maps and review others’ concept maps.

After reviewing pharmacy students’ concept maps, pre and post survey data and the post study interviews, it was apparent that a chasm existed between students’ perceived value of their colleagues’ distributed expertise and their
willingness to share their understandings. While students recognized and openly acknowledged the benefits of collaborative learning to access their colleagues wide and varied experiences of drug information, different disease states and treatment options, they did not actively share their concept maps nor did they actively review others’ maps. They did, however, communicate with their work groups, submit group case study assignments, and present cases in online workshops.

Benefits of Distributed Expertise

In the post study interview, students were asked what aspects of collaborative learning they found beneficial to their learning. Students reported they liked to “hear others’ perspectives [and] multiple views and opinions [as there are] lots of pieces in the health care puzzle.” Other responses included: “everyone is good at something [as we all] work in different areas of pharmacy,” “division of labor helps to get projects done more efficiently,” “[you] have to learn more to argue your point,” and “[I] check my ideas against the group before I turn in an assignment for a grade.” Their responses suggested they understood and had enjoyed the benefits of the dispersed expertise inherent in their online learning community.

Limited Sharing of Maps

While students openly acknowledged the benefits of collaborative learning to access others’ opinions and expertise, they did not translate that into sharing their concept maps. A majority of the students (a) did not ask anyone in their group to review their maps, (b) did not ask anyone outside of their group to review their maps and (c) did not ask their teachers to review their maps.
Technology Experience did not Affect Collaboration

Deep Strategics shared and reviewed maps significantly more than Technology Experts. However, students’ overall use/experience and self efficacy with computers was negatively correlated with sharing maps and reviewing maps. Why were students with high computer use/experience and high self efficacy with computers less likely to share their concept maps and review others’ concept maps? One explanation might be that the measure employed was not sensitive to this audience. However, the revised two-item use/experience index had acceptable face validity and reliability and was significantly correlated with pharmacy students’ self efficacy with using computers. One would think students with extensive use/experience and confidence in their ability to use computers would be the most technologically able to share their concept maps and review others’ maps on the public concept map server. But in this online learning environment, there appeared to be mitigating factors in pharmacy students’ communicative processes.

Empirical evidence from this study indicated that after three years in the NTPD program, students’ efficacy with using educational technologies to learn collaboratively is still perplexing. The researcher asked students to visualize their understandings using concept mapping. They did so and posted their maps on the public concept map server without difficulty. The researcher also asked the students to actively share their maps and to review other students’ concept maps. The students, as indicated above, did not share their maps or review others’ maps. Was this a good idea? Was it asking them to do too much to learn to use a new tool and
integrate it in their collaborative learning activities in too short a period of time? What is the process of adopting and gaining mastery over a tool that must occur before students can learn and act creatively with a new tool? The results indicated using concept mapping to map one’s understandings is not the same as using concept mapping creatively to learn in new ways. The next section suggests students need to master the creative uses of educational tools before they can be expected to learn collaboratively in an online learning community.

Informating with Tools as a Prerequisite to Online Learning Communities

While the role of educational technology is often to transfer information from a library database to a student’s personal computer, this perspective of educational technology is limited to effective and efficient transmission and reception of information. While this function should not be criticized or overlooked, it should not be the only recognized role of digital educational tools. Educational technologies might be used not only to improve efficiencies of what is already being done, but also to help transform the learning process to reflect the ideals of constructivism and a dialogic mode of teaching and learning. In short, the role of new educational technologies should be to widen the possibilities for students to learn in new and creative ways.

Zuboff (1988) separated out transmissional vs. dialogic uses of technology. In her book: In the Age of the Smart Machine: The Future of Work and Power, Zuboff describes the two facets of computer technology as “automating” and “informating.” Automating describes computer technologies’ inherent strengths in
doing things faster, more efficiently, cheaper, more per hour and with fewer mistakes. Informating is the creative processes enabled by technology that allows for new ways of thinking and doing. To “informate” with technology, one must do something creative with it that was not possible without the technology. The Apple Classroom of Tomorrow built on this idea and found that capabilities of a particular educational tool coupled with pedagogical methods that took advantage of the technology’s capabilities “interact with and influence the ways learners represent and process information and may result in more and different learning” (Tierney, 1992, p. 1). Specifically, Tierney found learners shifted their understanding of documents as communicating ideas from linear to a layered arrangement and adjusted their understanding of their roles as learners from worker / receiver to creator / constructor (Maxwell & McCain, 1996).

If concept mapping provides the opportunity for students to informate and communicate with others about their learning, should it be made an educational standard? How can teachers equip students with tools and methods to move from automating to informing with educational technology tools? How can teachers design online learning communities where students can learn creatively and collaboratively with their peers using these tools? As a designer of the online nontraditional PharmD, the researcher’s job is to help NTPD students become experts with educational technologies so they can informate with them.
Steps Toward Informating with New Tools

Students’ ability to learn in new and creative ways in their online learning community presupposes students can use educational tools’ informative capabilities. In short, before a student can use a tool to its fullest potential, the technology must first become transparent to that student. That is, the student must have a tacit understanding and feel at ease with the tool before learning and communicating creatively with the tool. Before launching a new tool into a learning environment, teachers should first ask themselves and their students if the tool has informing potential. This dissertation argued concept mapping has the potential to help students visualize, manage and share their understandings with their colleagues.

Implement, train, and support the tool over time. Once a new tool has been determined to have informative possibilities, the teacher could implement, train, and support the tool over an extended period of time. This project was run for only one trimester. Pharmacy students were clear that this was not enough time to become comfortable with the concept mapping tool. They indicated they “were not used to [concept mapping] yet.” Asking the PharmD students to share their concept maps and review others’ maps before they had time to become comfortable with the tool might had been asking too much. These students were not only pressed for time, but they had just learned how to use the concept map tool. Sharing understandings is like teaching. Just as it is challenging to teach someone to play chess when you have just recently learned, it is difficult to share portraits of knowledge with a new tool that one does not yet fully understand.
Hands-on experience is required. Further, hands-on experience with the tool is necessary to move from novice to informator (Zuboff, 1988; Nonaka & Takeuchi, 1995). The empirical results from this study provide support for this claim. Pharmacy students who frequently made changes to their concept maps had higher total concept map complexity scores. This finding was not surprising, but was conceptually important for two reasons. First, that students used the concept mapping tool to visualize their sophisticated conceptual frameworks indicates they were, at some level, informating with the tool. Second, multiple theories on manipulating cognitive structure argued learning is gradual and takes place as students’ revisit their existing interpretations over and over. Ausubel’s (1968) progressive differentiation theory suggests students refine their conceptual frameworks by adding new concepts, restructuring existing concepts to make space for new ideas, or simply restructure one’s framework to make better sense of one’s overall knowledge base. DeBono’s (1967) lateral thinking and Spiro and Jehng’s (1990) cognitive flexibility theories suggest students systematically reconceptualize existing and newly formed conceptual frameworks because conceiving of a learning problem in a new or different way may lead to sudden insight. Gleitman (1991) further suggested that after struggling with a learning problem, it may be helpful for students to set it aside for a time to enable an unconscious restructurizing of the problem.
Cognitive flexibility theory suggested students criss-cross the conceptual landscape (Wittgenstein, 1953) of their understandings by viewing them from multiple, flexible perspectives. Returning to one’s concept map repeatedly to review and make changes to one’s knowledge base was just what these theorists had in mind.

Must train teachers to informate too. This project focused on training the students on the new tool but neglected training the teachers. Tierney (1992) found it took up to two years for teachers to adjust to and work with informating technologies, to implement them successfully, and integrate them into their instructional design. The implications of learning with digital tools promote the need for students and teachers to work collaboratively as they learn to use informative educational technologies. Experience is essential in recognizing educational technologies’ capabilities to creatively change the way we learn, teach and work. Teachers must be willing to acknowledge this and engage in collaborative learning with learners who may already possess a tacit understanding of informating with educational technologies. This role reversal, from teacher to learner, is a truly dialogical moment and might be encouraged in online learning communities.

If students and teachers are trained, given time to learn and get their hands on the learning technology repeatedly, they may begin to informate with the new tool. Once students can informate with the tool, learning and communicating with the tool in a learning community becomes a possibility.
Theoretical Implications of the Study

The key findings from this study were synthesized into a collaborative online learning community model for nontraditional students.

Collaborative Online Learning Community Model for Nontraditional Students

What this study failed to privilege in its design were the contextual requirements of an online nontraditional learning environment and an understanding of the time and experience needed to informate with a new tool. Learning is a function of the activity, context and culture in which it is situated. New information needs to be presented in an authentic context, a clear requirement of professional pharmacists, and learning requires social interaction and collaboration. The model also proposes that the ability to informate with a tool is a prerequisite to using that tool to learn and/or communicate in an online learning community.

This study’s multiple research hypotheses assumed direct relationships between constructs void of time, authentic learning and motivational factors. The hypotheses also made the faulty assumption that having the ability to create concept maps is the same as using the tool creatively to learn in new ways. For example, the researcher assumed students with high technology experience would be the most technologically able to share their concept maps and review others’ maps. Yet both sharing maps and reviewing maps were negatively correlated with both self efficacy and use/experience. The point is, technology experience, without consideration of the contextual factors of a learning environment or the informating process, was not helpful in describing if students would collaborate. Rather, what pharmacy students
chose to do in their online learning environment was determined primarily by their time, their authentic learning needs, motivational factors, not having enough time/hands-on experience with the tool, and their resulting risk analysis. These miscalculations in the study design created a learning environment in which the pharmacy students were either unable or unwilling to move past stage two of the proposed collaborative online learning community model for nontraditional students (see Figure 21).
Figure 21. Collaborative online learning community model for nontraditional students.
This researcher proposes learning in communities encourages multi-way dialogue among students and teachers to share understandings publicly vis-à-vis collaborative learning. Just as technology mediates communication as a function of a tool’s affordances (Innis, 1951), nontraditional students need to understand the learning possibilities and implications of learning in a learning community. A learning community might facilitate social construction of understandings in four iterative stages.

Stage One: Students Individually Express their Complex Understandings

First, students discover new concepts and conceptual relations and assimilate and/or accommodate the new information and restructure their conceptual frameworks individually. The NTPD students did this amazingly well considering the complexity of the information with which they were presented. The amount of information available to pharmacy students upgrading their individual understandings in the pharmacy workplace is staggering. The complexity of accessing, organizing, assimilating and accommodating large quantities of new information from the NTPD program into one’s existing conceptual understandings is a complex task. These pharmacists’ workplaces were filled with computers, drug information databases, formularies, journal articles, patient records and new understandings from their doctoral program. Integrating new understandings into their existing workplace knowledge bases and processes was more complex still. While concept map complexity was not significantly correlated with most of the
study constructs, there were interesting findings in students mapping patterns and their resulting conceptual change processes that indicated they mastered stage one.

**Conceptual changes in concept maps.** This study measured the type and rate of NTPD students’ conceptual changes as represented by the changes in students’ concept map complexity scores over the course of the study. All pharmacy students’ concept map complexity scores increased in each of their mapping intervals and all students experienced both assimilation and accommodation on each of their concept maps as defined by Ausubel’s (1963) assimilation theory.

**Monitoring conceptual changes.** One of the goals of concept mapping was to help mid-career pharmacy students visualize their existing understandings and to monitor how their understandings changed as they made changes to their concept maps. Students were asked in the post study interviews if they found concept mapping useful in helping them to visualize how their understandings of the course materials changed over the semester. Students reported that while concept mapping was time consuming, they did find it to be a useful method to monitor their conceptual change processes. Click on this [audio link](#) to hear one pharmacist’s description of how concept mapping helped him monitor his conceptual changes. He said “I think that it really shows, from a learning perspective, [concept mapping] changed your thought process, or maybe you looked at it [and thought] that’s not what I wanted to do. So my whole focus was, as I saw things, or I realized I could delete those concepts and actually organize it more appropriate to the patterns I wanted to put there.”
Another group of PharmD students suggested concept mapping was useful for scaffolding their learning prior to assimilating or accommodating new information. Click on this audio link to hear four students describe how they used concept mapping to “create a road map” for their learning. The first student thought of “using the concept maps as a framework rather than an all inclusive guide. It’s easier for me to learn things in small parts and to digest them slowly.” A second pharmacy student suggested concept mapping “gave you more of a road map of everything you needed to learn during each lesson.” And the third pharmacist reported concept mapping “is an important tool to see where you are going and a rough outline of what you are doing.”

Stage Two: Share Understandings Publicly with Learning Community

Second, students share their new conceptual understandings publicly with others in their learning community. These public presentations of knowledge are necessary for all members of the learning community to see what their colleagues “know.” If the presented ideas are useful, all members of the community may benefit from the shared understandings. The pharmacy students all saved their concept maps to a public concept mapping server. As such, all students and all teachers had access to everyone’s concept maps at any time. Providing public access to students’ concept maps, however, had an unintended consequence. Two pharmacy students stated concept “maps are already available on the CMap-Exp server [so I] did not make an additional effort to share [them].”
Students all knew they could access one another’s concept maps at will. As such, making specific requests to have someone else review their maps may have been perceived as a waste of time in a system already providing ready access to all students’ concept maps.

Stage Three: Learning Community Peer Reviews, Critiques and Restructures

Proposed Understandings

Third, students peer review, critique and restructure the new understandings vis-à-vis community dialogue. A learning community either validates the propositional claims hypothesized in students’ shared understandings or discards them. The NTPD students did not progress to this stage because they were either unwilling or unable to share their understandings with the larger community.

Stage Four: Learning Community Adopts New Understandings

Fourth, if the new understandings are validated and accepted by the collective, the learning community uses the new understandings as part of its existing conceptual framework to acquire new information. The cycle then repeats itself as individuals in the community draw on community understandings to seek out and acquire new ideas.

Why were Students Stuck at Stage Two?

While the NTPD students successfully made it through the first two stages of the social construction of understandings cycle, they did not share and review one another’s understandings and progress to stage three. Why? After reviewing the post survey data, the researcher was interested in finding a bridge between pharmacy
students’ perceived value of the distributed expertise in their online learning community and their lack of sharing and reviewing others’ concept maps. To better understand this mismatch, a question was added to the post study interviews. Students were asked, “What, in your opinion, might have been done in this course to encourage more collaborative sharing of student and professor concept maps?”.

Students responses indicated they stopped after the second stage because (a) there were not given enough time to informate with the new concept mapping tool, (b) the tool and collaborative use of it were not privileged by the teacher or the course grading scheme, and (c) building collaborative learning communities is difficult and takes time.

Not Enough Time to Informate with the New Tool

The NTPD students suggested they needed “more time for concept mapping” and more time to learn how to use the concept map tool. They exclaimed the nontraditional program should “orient students to share maps from the beginning [in the] NTPD orientation” and in “online chat session[s] to discuss how to share maps.” They also recognized that they “need[ed] multiple semesters to concept map” and further suggested the “program should allow us to continue to map and provide technical and instructional support” for concept mapping.

The problem of not having an extended time period to informate with this tool was compounded by students’ limited time during the course. These adult learners had full time jobs, families and their remaining time was allocated for learning in their online degree program. When asked why they did not engage in
concept mapping or collaborative learning activities, students regularly cited their lack of time. They were “focused on the main assignments in the course.” They worked on their “maps done just before the assignment deadline,” and reported it “seemed presumptuous to ask someone else to take time to review my map when we are all short on time.” In addition to needing time to informate with a new tool, pharmacists employed a set of strategic criteria when making decisions on how to allocate their time.

**Tool and Collaborative Activities were not Privileged by the Grading Scheme or by the Teacher**

This section explores the contextual and pedagogical elements that need to be present in a learning environment so students may choose to collaboratively share their understandings. The following suggestions are the practical conditions of the proposed learning model to move students past stage two and onto stage three. These practical guidelines should be considered necessary and important conditions to designing an online learning environment. Students’ operative needs and resulting strategic behaviors do not go away simply because students are placed in an online learning community. The following design suggestions were constructed from students’ comments on their experiences using concept mapping.
Make it a priority. First, pharmacy students suggested concept mapping should be made a central part of the program’s existing collaborative learning activities. They promoted the idea to “use maps in workshops” and “share good maps as exemplars.” They also thought to make use of the flowcharting capabilities of concept mapping by “stop using SOAPs [and] replace them with concept maps for the workshops.”

Make it count. Second, concept maps should be scored for content accuracy and made a higher percentage of the final grade. One pharmacist suggested “the maps did not mean anything because they were not scored for content.” Others took a more moderate approach and suggested students would have worked harder on their concept maps if teachers “provided [an] incentive for sharing” by making “it an assignment, with a high point value to share maps with other students.” Other students suggested earning points by “critiquing others’ concept maps” and “creating group maps.”

Teachers have to walk the walk. Third, teachers should actively participate in learning and using the tool in collaborative learning activities. The NTPD students reported they did not find any value in reviewing teachers’ scaffolded concept maps because they were not as complex as their maps. It should be noted the lack of complexity in the scaffolded maps was not the fault of the teachers. The teachers were instructed, by the researcher, to construct concept maps containing “a few key concepts.” The proposed analysis was to look for these key concepts in

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68 SOAP is a acronym for: Subjective Objective Assessment Plan. This is traditionally a table on which students “work up” a problem based case.
students’ concept maps. Interestingly, pharmacy students viewed the lack of complexity in teachers’ maps as non-useful as opposed to a map of parsimonious key concepts proposed by their teachers.

One student bluntly stated “the professors’ maps were not good and therefore not helpful.” See Figures 22 and 23 to view the two teacher scaffolded concept maps provided to the NTPD students.

Figure 22. Teacher scaffolded concept map of anxiety and depression.
Figure 23. Teacher scaffolded concept map of Alzheimer’s disease.

The relative lack of complexity in each of these maps was the main reason the students did not find these scaffolded maps useful. Click on this audio link to hear four students explain why they did not find teachers’ scaffolded maps useful in mapping their understandings. The first student suggested the “concept maps professors put out were very quickly done and didn’t have a lot of detail. I thought the professors put up brief information, not very much, just to say it was done. I didn’t think they put a lot into it, so it wasn’t helpful to review their concept maps.” A second pharmacist agreed with “unfortunately, the professors’ concept maps… were usually pretty crummy… it didn’t look like the professor put a bunch of time into it, and that was a little frustrating.” The third PharmD student repeats the theme with “… I went and looked at [a teacher’s map] and it was very basic. There might
have been five little circles\textsuperscript{69} and that was it. He never went into the detail I always went into, so that wasn’t very helpful to me.” The fourth student did not know teachers were constructing scaffolded maps when she reported “I did not look at a [teacher’s] map. I did not know [anyone] had one out there, so no, I did not make any changes [to my maps] according to their maps.”

These three criteria, make it a priority, make it count, and teachers have to walk the walk, taken together formed a time / authentic learning / grade risk filter through which students made decisions.

**Time / authentic learning / grade risk analysis.** These pharmacy students enrolled in the NTPD program to update their pharmaceutical care understandings and skills to maintain their career mobility, provide opportunities for career advancement, to be more informed pharmacists, and to put “PharmD” after their name. To accomplish these goals, these pharmacy students required authentic learning tasks. For these students, authentic learning included new information they could use in their pharmacies and tools that helped them to clarify their existing understandings and organize their learning. However, while they openly recognized the authentic learning value (shared expertise) and the time value (division of labor) of collaborative learning, pharmacy students did not actively share their concept maps or review others’ maps because their academic success (i.e., grade) was not directly affected by either activity.

\textsuperscript{69} The student was referring to the number of concepts on the teacher’s scaffolded concept map.
This study’s findings in the context of this learning model suggest
nontraditional students, when faced with severe time limitations, link their authentic
learning requirements to their academic success as defined by their final grade. In
other words, when asked to engage a new learning tool, pedagogy, or new
information, these pharmacy students asked themselves the following decision
making questions: (1) do I want to spend my time on this activity, (2) was the
activity prioritized in the grading scheme, (3) what are the learning benefits of doing
it, and (4) are the teachers doing it too? All of these recommendations point to time,
authentic learning and grading; conditions which will ensure their activities will
affect their academic success.

This finding may sound overly practical, and that is the point. These working
professionals were interested in learning, but the context within which they learned
had to be designed specifically to meet their risk analysis requirements. Learning to
use concept mapping to share their understandings required spending time with the
tool to understand how it could enable the sharing of understandings across their
learning community. While social construction of understandings appealed to many
pharmacy students, spending the time to learn to do so meant taking a risk with their
time. The practical fault of this research project was it introduced a new learning
tool to a group of nontraditional students who could not afford to take risks on time
intensive activities that were not made a grading priority. The conditions inherent in
this risk analysis were important to these mid-career pharmacists and should
therefore be taken seriously when designing online learning environments.
Building Learning Communities is Difficult

Building and nurturing learning communities to the point where they are willing and able to share, critique and adopt new understandings takes time and repeated interactions with the entire community. These NTPD students had worked together for three years prior to this study, yet they had mostly worked in small groups. Students’ interview responses indicated they were more likely to ask students in their group than students outside their group to review their concept maps, and were least likely to ask their teachers. One representative comment for why students’ limited sharing was only within their group was “[my] group members are all close friends, I trust their opinion.”

Students’ communication about concept mapping was also limited to their small group. The few students who did share their concept maps and review others’ maps did so primarily with students in their group and not with their larger learning community. This was not surprising as these NTPD students had been working together, in their work groups, on multiple collaborative projects, for three years when this project was implemented. These findings did not suggest, however, that students were not communicating within their group and/or the larger learning community. It merely suggested the concept map tool did not open new channels of communication between students and others outside of their group.
While choosing to learn in comfortable environments is understandable, teachers need to find new ways to make the larger online learning community comfortable to encourage wider collaboration and communication. These pharmacists also faced multiple challenges to building a collaborative learning community.

**Extrinsic motivation.** Many students were individually competitive and extrinsically motivated and were not compelled to make the extra effort to share their concept maps. When students discovered the teachers did not make concept mapping a course priority in their participation or in the grade scale they made a strategic decision. Students suggested because the “total point value for concept maps was low, maps were not perceived as being important,” and “sharing was not required, so no one did it.” These pharmacists were also concerned that sharing their concept maps was equivalent to cheating. One pharmacy student asked “why should someone else get a free ride off of my work?” They were also unhappy when they discovered their concept maps were not graded for content accuracy. Click on this audio link to hear a student suggest all students “should be held to a standard to be able to achieve a goal like using concept maps to be able to achieve a certain content.” This focus on individual success is problematic when the goal of a learning community is public sharing, peer critique and communal dialogue.

**Pride.** Students suggested experienced pharmacists “think they have a good handle on things” and “may not want constructive criticism.” One pharmacy student suggested “sharing your maps is like being on a stage and being critiqued.” Being critiqued by one’s peers was a potentially uncomfortable position when students had
to engage in a public display of understandings. Yet, public evaluation of new ideas is
the central premise of social constructions of knowledge. Further, after pointing out that “everyone learns differently” one student wondered “I am not sure how looking at others’ concept maps will help me.” Teachers need to struggle with this attitude and help students realize the fact that everyone learns differently is an asset to the community. Diversity of understandings helps all members approach new information with multiple perspectives.

Concept maps were either all the same or were non-useful. The students also questioned if there were differences among others’ understandings when they said the “subject matter was straight forward,” “we all have similar understandings due to similar lectures [and] resources,” and “maps are just an outline of the coursework.” They also questioned the quality of their own maps. “I did not think my maps were all that good.” They further questioned the usefulness of others’ maps because they “were not clear and it was hard to follow their thoughts,” and “others’ maps did not have any earth shattering discoveries.” Again, it will be a challenge to help students informate with new tools so they can learn in creative ways and communicate about their new ideas. These pharmacists are all bright people. I find it hard to believe they have nothing to learn from one another.

Implications for Practice

While a single study cannot provide a sound model for enabling social construction of understandings in nontraditional online learning communities, this study makes the following recommendations. First, recognize that informing with
a new tool takes time, hands-on experience and may be a pre-requisite to using the tool to learn and communicate in a learning community. Second, for students to move past public presentation of understandings and into collaborative peer review of others’ ideas, teachers must understand the decision making risk analysis nontraditional students employ. Before implementing collaborative activities and/or educational tools that take a substantial amount of time, teachers should design their online learning environments with the following contextual requirements in mind:

- demonstrate students’ authentic learning needs are being served,
- make the new activity and/or tool a priority through both teacher participation (i.e., teachers have to “walk the walk”) and grading,
- show students how the activity and/or tool helps them manage their existing understandings and learn new information, and
- recognize the implementation and subsequent adoption of the new activity and/or tool into the learning community will take multiple semesters.

Third, building working learning communities is difficult. The challenge, however, is worth the effort. Once students are able to informate with a new tool, their learning environment requirements are met, and the learning environment privileges collaborative activities, students may be able to socially construct understandings in their learning community.
Implications for Conceptual Change

If conceptual change theories are rubrics for the contextual learning conditions within which students change their existing conceptual frameworks based on new information, then the proposed learning model is an advancement of the conceptual change literature. In short, the collaborative online learning community model for nontraditional students suggests that before teachers can expect mid-career students to engage in conceptual change processes within their learning community, the change has to be on their terms. Further, before a learning community can engage in conceptual change, students must have mastery over the tools they use to communicate their understandings to their colleagues.

The learning model suggests students employ a risk analysis filter that screens all new information and learning activities based on their time, their authentic learning goals and how those goals relate to their final grade. Assimilation and/or accommodation processes seem to be secondary to this initial screening. As noted above, these terms are less conceptual than practical, but were the dominant filters through which these professional pharmacy students made decisions.

Strike and Posner’s (1982) original conceptual change model assumed learning was an entirely rational process. After a stiff critique from Pintrich, Marx and Boyle (1993) on the grounds their conceptual change model ignored social, collaborative, and contextual influences, Strike and Posner (1992) acknowledged the importance of these factors and revised their conceptual change model accordingly. This study’s findings, as represented in the proposed model, suggest students
employ a strategic risk analysis filter before they are willing to engage in community conceptual change activities. This filter, however, was constructed by the nontraditional pharmacy students based on the social (e.g., students were comfortable in their groups), collaborative (e.g., pharmacists acknowledged the benefits of collaborative learning as long as it was helpful), and contextual (e.g., students’ time and authentic learning needs) factors in their online learning community. In short, this study’s findings support the argument that conceptual change models require contextual factors to accurately predict when and why students will change their existing understandings in learning communities. Integrating this model into and enhancing it with existing conceptual change and learning community models is part of the researcher’s larger research program. Implications for Concept Mapping

All pharmacy students successfully built and saved their digital concept maps to a public server and most successfully introduced concept mapping into their repertoire of learning strategies. This experience suggests concept mapping is a viable educational technology tool to help nontraditional students visualize their conceptual frameworks. While its use as a conduit for social construction of understandings was limited in this project, concept mapping should be retested under the model’s proposed contextual learning conditions and over an extended period of time. This was also the first study using concept mapping with pharmacy students. The literature on concept mapping was extended by both the measurement issues found with and the potential validity threats to the concept map scoring
instrument. These and other recommendations for methods and measurement are explored in the next section.

Recommendations for Methods and Measurement and Future Research

This chapter concludes with recommendations for methods and measurement and suggestions for future research.

Recommendations for Methods and Measurement

After reviewing data from the two surveys, the 110 concept maps, and the post study interviews, it was clear many of the instruments used in this study might be modified to support future research on concept mapping and nontraditional students in online learning environments.

Measurement Issues with the Concept Map Scoring Instrument

Scoring digital concept maps for complexity was difficult due to the inherent strain between the flexibility of the concept map tool and the conformity of the concept map scoring instrument. Three distinct instrument problems created challenges when scoring students’ concept maps for complexity.

Proximity vs. links problem. Some PharmD students did not link their concepts with links, as defined by the concept map tool, to show conceptual relationships. They instead positioned concepts in space and used proximity to show relationships between concepts. Students’ grouping of concepts to show conceptual relationships was directly related to Gestalt theory which suggests concepts may be grouped by proximity, similarity, closure and simplicity. The concept map scoring instrument, however, did not take Gestalt principles into consideration when scoring
students’ maps. See Figures 24 and 25 for examples of concept maps constructed by students who used proximity to show conceptual relationships.

The problem was the concept map scoring instrument did not account for any conceptual relationships other than direct conceptual links as labeled by the concept map tool. In other words, students who used proximity of concepts to show relationships did not receive credit for those links. The concept map tool should add an option to its auto layout tool that clusters concepts in tight configurations based on their relative distance to and similarity with other concepts.

Figure 24. Concept proximity used to show conceptual relationships: example one.
Labeling problem. Some students used concepts to represent links and vice-versa. Because the instrument scoring rubric was heavily based on counting instances of concepts, using links to represent concepts caused scores to be artificially low. The concept map tool interface would benefit from a feature that reminded the student regarding what she was adding (e.g., link or concept) to her map.
Another labeling problem resulted when students attempted to link concepts to one another and failed. The result was a concept linked to a blank concept box, often hidden behind the concept to which the student had intended to link. A search and delete feature for blank links and blank concept boxes should be added to the concept map tool.

**Direction of relationship problem.** A major problem with the concept map tool interface was the hidden direction of conceptual relationships. When constructing a concept map, students linked concepts to other concepts with conceptual relationships. The direction of the conceptual relationships (i.e., link pulled from concept X to concept Y) was recorded by the concept mapping software. The problem was the concept map tool, in the default view, did not show directional arrows to signify the direction of the conceptual relationship. When the auto layout feature was used to standardize the hierarchical structure of students’ concept maps, any maps that had their conceptual relationships linked “backward” were flipped upside down. See Figure 26 to view a slice of this student’s concept map with “backward” conceptual links. Click on this [link to view] the entire concept map.
Figure 26. Student’s concept map with “backward” conceptual links.
The problem was upside down concept maps yielded significantly higher complexity scores because what were originally single instances of branching became multiple cross-links. The scoring differential was substantial because each cross-link was worth 10 points while each instance of branching was worth only three points. The unfortunate result of this design problem was the removal of one student from the research hypotheses analyses. While this measurement problem resulted in the removal of a single student, and was therefore not a reason to stop the study, the concept map tool should be redesigned to show the direction of conceptual relationships in its default view. This might help students better visualize and understand the direction of their conceptual relationships within their concept map.

Potential Validity Threats to the Concept Map Scoring Instrument

There were three potential validity threats to the concept map scoring instrument. First, sophistication of understanding was equated with high concept map complexity. While quantity of concepts and the relationships connecting them may be an initial indicator of understanding and may be useful at tracking students’ conceptual change processes, quantity of concepts does not necessarily equate to sophistication of understanding. For instance, several students reported their concept maps became more parsimonious as they learned. To better understand this threat, pharmacy students were asked in the post study interviews if they were able to eliminate concepts and links from their concept maps as they learned more and developed more sophisticated understandings. They were then asked what they
made of this phenomena. These PharmD students responded they did eliminate concepts and links from their concept maps as they learned more. Their rationale for doing so was consistent with them developing more sophisticated understandings. They reported “getting rid of the frivolous information and clutter,” “maps were a changing framework and changed as my thought processes changed,” “I consolidated my maps to streamline them,” “sometimes I deleted concepts I deemed not to be as important,” “once I understood something, I no longer needed to show it on my map,” “some details were overkill [and] smaller maps made it easier to visualize important ideas,” and “[it was] beneficial to tie things together after adding a new concept.” This need for parsimony fits the proposed learning model. Doctoral students required a high level of sophistication of understandings to comprehend their existing understandings well enough so they could assimilate and accommodate new information. The more parsimonious students could make their maps, the more time efficient their conceptual change processes might have been.

Second, concept maps were not scored for content accuracy. While pharmacists’ concept maps were purposefully not scored for content accuracy, students responses to the post study interviews indicated they would have worked harder on their concept maps if their maps had been scored for content accuracy. That pharmacy students might not have put all of their understandings on their concept maps weakens the argument that concept maps were accurate representations of their conceptual networks. The researcher purposefully chose to study concept mapping as a learning tool and learning process by which practicing
pharmacists could share their understandings (accurate or not) in their online learning community. The problem was this goal was not congruent with students’ decision making process. That is, pharmacy students were not interested in allocating time to “try out” a new educational tool.

Third, a majority of PharmD students’ concept maps were constructed as visualized outlines of other transmissible formats. This threat was supported by post study interview responses to the statement: “Tell me what thinking process you went through to create your first concept map.” The number one answer was: “I used an outline from the lecture notes to construct my first concept map.” This response too made sense within the context of the proposed collaborative online learning community model for nontraditional students. Pharmacy students made a choice based on time, their authentic learning needs, previous NTPD course experiences, and their final grade. The concept mapping assignments took a substantial amount of time and were not prioritized in the grading scheme. To efficiently complete the concept mapping assignments, students outlined their concept maps based on lecture outlines, which accomplished their goal of doing enough to get their concept map assignments finished and submitted.

Revision of Assimilation and Accommodation Measure

All students had instances of both assimilation and accommodation during all four of their mapping intervals. This was a result of using an assimilation and accommodation measure that was designed for less complex concept maps. The students in this study were professional doctoral students mapping drug interactions.
of Alzheimer’s disease as related to elements of Parkinson’s disease, not fifth
graders mapping the rain cycle. The sheer amount of information these mid-career
professionals added to their concept maps overwhelmed the ability of this
instrument to measure differences in assimilation and accommodation during each
mapping interval. This instrument needs to be tuned to support the needs of
researchers studying concept mapping in nontraditional student populations.

Possible changes to this instrument might include the following. For an
instance of assimilation, the total number of concepts added to a map should be
increased from ten to 20. For an instance of accommodation, the addition or deletion
of concepts from the first, second or third hierarchical levels of a map should be
increased from “one or more” to “five or more.”

Revision of Learner Type Indices

The use/experience and ASSIST indices should be revised and retested to
determine if they have continued value in clustering professional adult students into
learner types. This is important because developing a better understanding of what
nontraditional students bring to their learning environment is critical to designing
effective learning spaces.

Use/experience revision. The use/experience index was designed for and
tested on undergraduate students. As such, the index might be revised to more
accurately capture students’ life experiences with technology in their workplace.
Specifically, it needed to be updated to understand the detail within the high range
in use/experience among nontraditional students. These pharmacy students, for
example, had ranges over 20 years on computer ownership, 29 years on using computers in the workplace, 14 years on computers use for education, 118 months on home internet access and 57 hours on weekly hours spent working on a computer. This wide distribution of experience may have been due to partially students’ age and workplace differences. First, these pharmacists worked in different job environments that required different levels of computer use. For example, Deep Strategics had a higher mean score on average weekly hours of computer use. Explanations for this might include efficient use of computer time at work by Technology Experts. It is also possible the two learner types used computers at work in different ways resulting in different hours logged. Second, because nontraditional students are older, they may have had less computer experiences then their younger colleagues.

This instrument might be adjusted to collect more information on: students’ efficiency with using computers, the percentage of their work day they are required to use a computer, on what tasks they used computers at work, and the percentages of their professional and educational careers in which they regularly used computers.

ASSIST revision. The ASSIST was also designed for and tested on undergraduate students. As such, the ASSIST indices should also be modified to account for the different characteristics of nontraditional students. Three ASSIST indices were left out of the formula for defining the learner types due to their low reliability. These three indices, however, were conceptually interesting and worth
revising. The learning as transforming index was related to dialogic pedagogy and the learning as reproducing index was related to transmissional pedagogy. Further, the transmitting information index was related to the surface approach to learning and the Entwistle, McCune and Walker (2000) suggested the encourages understanding index was related to the deep approach to learning. Although unreliable in this study, these indices are conceptually interesting and should be modified to account for the unique characteristics of nontraditional students. For example, modifications to the learning as transforming index might include the following changes to its four scale items:

- Being able to use the new information you learned in your professional workplace
- Understanding new material for yourself based on your learning needs
- Seeing how new information fits into your learning community’s understandings
- Developing your career as a professional

**Future Research**

Additional research is needed on the collaborative use of concept mapping as a conceptual change agent in online learning communities. Future research is warranted because educators need to understand how to design online learning environments in which students can collectively share their existing expertise and work together to understand new information. This dissertation concluded with a collaborative online learning community model for nontraditional students that

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70 The Encourages Understanding index did have acceptable reliability and was included in the formula for defining the learner types.
might be used as a set of guiding principles to design online learning environments. While there have been decades of research on collaborative learning, conceptual change, concept mapping and learning communities, the proposed learning model needs further analysis.

**Should Concept Mapping be a Standard Tool in the NTPD?**

Is this tool worth introducing to students when they enter the nontraditional PharmD program? What if concept mapping was introduced at the beginning of the program and made part of the standard orientation? What if it was given the same amount of emphasis as all of the other tools? It might be adopted at the same rate as other technologies and allow students to informate with the tool at an earlier point in their program. In short, the next study should ask if public visualization of understandings is a centerpiece of students building socially constructed understandings in an online learning community.

Such a study should include the following. The study should be run again with more students, a more balanced gender ratio and for multiple academic semesters. The methodology of the next study should employ appropriate qualitative methodologies to triangulate the quantitative results with open ended survey responses and personal interviews. Using the proposed learning model and its implications for practice as a guide, new constructs should be added to the apriori learner type formula to provide a richer description of what nontraditional students bring with them to their learning environment. Further, the existing learner type constructs (e.g., ASSIST and use/experience indices) might be modified to more
accurately capture the learning and technology experiences nontraditional students bring with them to their online learning communities.

Similarly, a new set of research hypotheses should be generated based on the new model to again test if concept mapping may act as a conduit for social construction of understandings in online learning communities. One of these new hypotheses should be based on students building community level concept maps. This research focused on individuals building concept maps and then sharing their constructed understandings within their learning community. An entirely new realm of social construction of understandings may be revealed if students collaboratively build a community map over multiple academic semesters. The new version of the IHMC CMap concept map software provides for this opportunity.

Forming Online Learning Communities?

To take full advantage of socially constructed understandings, the researcher intends to study how learning communities formed over time in the NTPD program. How strong are the small group community ties currently? How were these relationships formed? Stacy (1999, p. 24) argued that dialogue in work groups establishes a “secure zone” for students to construct knowledge and present their individual understandings to their peers before committing their ideas to the larger learning community. How can the secure zones established in students’ small working groups be expanded to the entire learning community? Maybe secure zones can be expanded to the entire learning community using the student risk analysis results. Do learning communities have the same practical requirements for new
learning methodologies as they do for using new tools? If so, how can collaborative learning be privileged along with the tool so students will be comfortable with sharing their understandings? Once students are willing to put forth the effort to share and review understandings, how do learning communities use new tools to legitimize new understandings?

**Informating Transformation Process?**

It is important to figure out the process by which an educational technology is adopted by students and at what point they can informate with the tool. One approach to this problem is to look at the range of educational technology tools and the range of applications the NTPD students currently use. For example, do the students use a particular tool for individual learning, note-taking, communicating with other students, and/or organizing their existing understandings? A study design might have students reflect on how they used previous tools including: how they were introduced to the tool, how they become proficient at using the tool, and at what point the technology become transparent to the student. In short, what process did pharmacy students go through to informate with tools over time?

Does learning style affect the informating process? It might also be worthy to explore if learning styles affect the process of learning to informate with a tool. For example, some pharmacists responses indicated (click on this audio link to hear their responses) concept mapping did not fit their preferred learning styles. The first student likened concept mapping to note taking and reported he “wasn’t all that in favor of concept mapping because it seemed to me that we were asked to use it to...”
organize our notes… and that is not the way I learn. It was foreign for me to do that. I have gone through 12 years of schooling and I have never taken notes, so that is why I was struggling with this.” The second pharmacist was clearly not a visual learner as she stated “I don’t really learn in diagram, so it’s kind of hard for me to use it in my studying.” The third pharmacy student was a self proclaimed “linear thinker” and had a “problem learning in that web kind of way. I need to be much more linear. So maybe if I would have constructed my concept maps in a more linear fashion, like straight up and down, I would have been much better off because [concept mapping] just seems too disorganized for me.”

If learning style is a modifier of moving from novice to informator, it may be prudent to give all entering NTPD students a learning styles inventory at the beginning and end of their doctoral program.

Measure the Success of Concept Mapping?

Sharing understandings in an online learning community is only one application for concept mapping. How else might the tool’s success or failure be measured? The success of a tool depends on what it is used for and if the desired outcome is achieved.

Diagnostic or consulting tool. Concept maps might be used as a diagnostic or consulting tool. This application of the tool might help students integrate their online NTPD community learning activities with their professional practices. The study might focus on their ability to informate with concept mapping as a transferable skill. That is, in addition to what students learned in the NTPD
program, how they learned is equally important. Students might take the tools and methods they developed in the NTPD program and transfer them to their work environment. Students might enrich their work communities with new tools and new ways to communicate and learn with their colleagues. In short, how do students transfer learning community practices from school to work? These transferable skills may be especially beneficial in ad hoc communities to get everyone’s ideas out in the open and solve a problem (e.g., a SARS treatment team). Such a study might also measure the strategic and deep methods of informating with the tool as transferable from school to professional practice.

**Group communication tool.** Concept mapping might be studied as a group communication tool. How do groups of users use the tool to communicate complex ideas? For example, a patient, doctor and pharmacist might use concept mapping to help them communicate their varied understandings of and plans for a patient’s long term management of low grade non-Hodgkin’s lymphoma. Will this informative use of the tool build a better heath care team to provide better care for the patient?

**Authentic problem solver tool.** The tool might help solve complex problems that transcend the factual base of the didactic materials learned in the NTPD program. Brown’s (2000) study of XEROX copy machine service technicians revealed how, through dialogue, the technicians added to and drew from the technician community’s socially constructed copy machine fix-it solutions. Pharmacists might use concept mapping to bring their professional experiences and problems into a public visualized environment. For example, one student laminated
her concept maps and shared them with her colleagues at work, and others color

coded their maps to indicate dangerous drug interactions.

**Concept Mapping and Communication?**

How is concept mapping legitimized in students’ communicative practices? If communication is a necessary condition of collaboration and learning community processes, then how are students using the tool to communicate? Results suggested communicating about concept mapping and collaborating (i.e., sharing and reviewing concept maps) were inextricably tied. This finding was in line with Johnson, Johnson and Holubec (1993) who suggested communication is a critical component in collaborative learning. But how do communication, concept mapping and collaborative learning interact with online learning communities? Are students using the tool to send new information, receiving information, ask for advice, to give advice, ask questions or to be supportive of others’ ideas?

Further, what are the communicative uses, issues and problems with visualization of knowledge? How can visualizing understandings can help students communicate their procedural and tacit understandings explicitly within their learning community. What if E-mail and threaded discussions were removed from the NTPD learning environment? Would students then use concept mapping as a communication tool? These and other questions about the tool’s communicative and informative capabilities are worthy of further analysis.
Maintaining Learning Communities?

One of the major themes of this chapter is time. It takes time to learn to informate with new tools. It also takes time for learning communities to form, establish patterns of behavior and learn to socially construct understandings. These pharmacy students are members of the NTPD program for over three years. After putting that much time and effort into building efficacy with tools and building learning communities, the learning community should be maintained post graduation. How do students maintain their position in their learning community after they graduate from the NTPD program?

The current Ohio State University policy is to turn off all access to online learning environments and communication tools after students graduate from the University. The University’s license agreements with various tool vendors restrict it from providing Ohio State alumni access to online learning environments and all of the tools therein. This immediate problem⁷¹ calls for a policy definition study. One of the researcher’s immediate projects is to secure a grant to fund a pilot project where the online learning environment and students’ access to existing tools is maintained for an extended period of time post graduation.

This research program will continue to focus on finding, implementing, assessing and revising new educational technologies, pedagogies and methodologies to help nontraditional students learn in new and creative ways in online learning communities.

⁷¹ The students in this study graduate from the NTPD program during the 2003-2004 academic year.
APPENDIX A

INSTRUMENTS

All measures, instruments and methodologies were cleared through the Behavioral and Social Sciences Institutional Review Board at The Ohio State University. Protocol # 02E0130.

Sharing Maps Index (Post Study)

- During the 16 weeks of Patho 3, how many times did you encourage other students to review your concept map(s) on the CMap-Exp server?
- During the 16 weeks of Patho 3, how many times did you encourage your Patho 3 Professor(s) to review your concept map(s) on the CMap-Exp server?
- During the 16 weeks of Patho 3, how many times did you directly give (that is - you gave your concept map(s) as a "gif" file or as a paper printout) a copy of your concept map(s) to another student?
- How did you give a copy of your concept map(s) to other students

Reviewing Maps Index (Post Study)

- During the 16 weeks of Patho 3, how many times did you review other students’ concept map(s) on the CMap-Exp server?
- After reviewing another student’s concept map on the CMap-Exp server, I always made changes to my concept map(s).
- During the 16 weeks of Patho 3, how many times did you directly receive (that is – someone gave you their concept map as a “gif” file or as a paper printout) a copy of another student’s concept map?
- How did other students directly give you their concept map(s)?
• When I directly received a concept map from another student, I always reviewed their concept map.
  o (1) Strongly Agree
  o (2)
  o (3)
  o (4) Neither Agree or Disagree
  o (5)
  o (6)
  o (7) Strongly Disagree

• After receiving a concept map directly from another student, I always made changes to my concept map.
  o (1) Strongly Agree
  o (2)
  o (3)
  o (4) Neither Agree or Disagree
  o (5)
  o (6)
  o (7) Strongly Disagree

• Reviewing other students’ concept maps helped me to better understand and map my understandings of Patho 3.
  o (1) Strongly Agree
  o (2)
  o (3)
  o (4) Neither Agree or Disagree
  o (5)
  o (6)
  o (7) Strongly Disagree

• After receiving an E-mail notice that a Professor's concept map was on the CMap-Exp server, I always reviewed the Professor's concept map.
  o (1) Strongly Agree
  o (2)
  o (3)
  o (4) Neither Agree or Disagree
  o (5)
  o (6)
  o (7) Strongly Disagree
• After reviewing a Professor's concept map, I always made changes to my concept map(s).
  o (1) Strongly Agree
  o (2)
  o (3)
  o (4) Neither Agree or Disagree
  o (5)
  o (6)
  o (7) Strongly Disagree

• Professors' concept maps helped me to better understand and map my understandings of Patho 3.
  o (1) Strongly Agree
  o (2)
  o (3)
  o (4) Neither Agree or Disagree
  o (5)
  o (6)
  o (7) Strongly Disagree

Reviewed from Whom Index (Post Study)

• How many times did you ask students in your group to review your concept map(s)?
• How many times did you ask students outside of your group to review your concept map(s)?
• How many times did you ask your Patho 3 Professor(s) to review your concept map(s)?
• Look at your answers above and notice whom you most often asked to review your concept map(s). Why did you most often ask this particular group of people to review your concept map(s)?
• How many times did you review concept maps constructed by students in your group?
• How many times did you review concept maps constructed by students outside of your group?
• How many times did you review concept maps constructed by your Patho 3 Professor(s)?
• Look at your answers above and notice whose concept maps you most often reviewed. Why did you most often review concept maps constructed by this particular group of people?
ASSIST Learning Styles Indices\textsuperscript{72} - (Pre Study)

This questionnaire has been designed to allow you to describe, in a systematic way, how you go about learning and studying. The technique involves asking you a substantial number of questions that overlap to some extent to provide good overall coverage of different ways of studying. Most of the items are based on comments made by other students. Please respond truthfully, so that your answers will accurately describe your actual ways of studying. This information is very important, so please take time to thoughtfully answer each question.

A. What is Learning?

When you think about the term “LEARNING,” what does it mean to you?

Consider each of these statements carefully, and rate them in terms of how close they are to your own way of thinking about “Learning.”

- (1) Very Close
- (2)
- (3)
- (4) Neither Close or Not Close
- (5)
- (6)
- (7) Very Different

a. Making sure you remember things well.
b. Developing as a person.
c. Building up knowledge by acquiring facts and information.
d. Being able to use the information you’ve acquired.
e. Understanding new material for you.
f. Getting on with the things you’ve got to do.
g. Seeing things in a different and more meaningful way.

\textsuperscript{72} Further information on the development and use of the ASSIST can be found in Tait \& Entwistle (1996) and Tait, Entwistle \& McCune (1998).
B. Approaches to Learning

The next part of this questionnaire asks you to indicate your relative agreement or disagreement with comments about studying made by other students. Please work through the comments, giving your immediate response. In deciding your answers, think in terms of your NTPD courses. It is also very important that you answer all the questions.

(1) Strongly Agree
(2)
(3)
(4) Neither Agree or Disagree
(5)
(6)
(7) Strongly Disagree

Try not to use “Neither Agree or Disagree” unless you really have to, or if the statement cannot apply to you or your course.

1. I manage to find conditions for studying which allow me to get on with my work easily.

2. When working on an assignment, I’m keeping in mind how best to impress the Professor.

3. Often I find myself wondering whether the work I am doing here is really worthwhile.

4. I usually set out to understand for myself the meaning of what we have to learn.

5. I organize my study time carefully to make the best use of it.

6. I find I have to concentrate on just memorizing a good deal of what I have to learn.

7. I go over the work I’ve done carefully to check the reasoning and that it makes sense.

8. Often I feel I’m drowning in the sheer amount of material we have to cope with.

9. I look at the evidence carefully and try to reach my own conclusion about what I’m studying.
10. It’s important for me to feel that I’m doing as well as I really can on the courses here.

11. I try to relate ideas I come across to those in other topics or other courses whenever possible.

12. I tend to read very little beyond what is actually required to pass.

13. Regularly I find myself thinking about ideas from lectures when I’m doing other things.

14. I think I’m quite systematic and organized when it comes to reviewing for exams.

15. I look carefully at Professors’ comments on my course work to see how to get higher grades next time.

16. There’s not much in my NTPD courses that I find interesting or relevant.

17. When I read an article or book, I try to find out for myself exactly what the author means.

18. I’m pretty good at getting down to work whenever I need to.

19. Much of what I’m studying makes little sense: it’s like unrelated bits and pieces.

20. I think about what I want to get out of this course to keep my studying well focused.

21. When I’m working on a new topic, I try to see in my own mind how all the ideas fit together.

22. I often worry about whether I’ll ever be able to cope with the course work properly.

23. Often I find myself questioning things I hear in lectures or read in books.

24. I feel that I’m making good progress, and this helps me put more effort into the work.

25. I concentrate on learning just those bits of information I have to know to pass.

26. I find that studying academic topics can be quite exciting at times.
27. I’m good at following up some of the reading suggested by Professors.

28. I keep in mind who is going to grade an assignment and what they’re likely to be looking for.

29. When I look back, I sometimes wonder why I ever decided to come here.

30. When I am reading, I stop from time to time to reflect on what I am trying to learn from it.

31. I work steadily through the term or semester, rather than leave it all until the last minute.

32. I’m not really sure what’s important in lectures so I try to get down all I can.

33. Ideas in course books or articles often set me off on long chains of thought of my own.

34. Before starting work on an assignment or exam question, I think first how best to tackle it.

35. I often seem to panic if I get behind with my work.

36. When I read, I examine the details carefully to see how they fit in with what’s being said.

37. I put a lot of effort into studying because I’m determined to do well.

38. I gear my studying closely to just what seems to be required for assignments and exams.

39. Some of the ideas I come across in NTPD courses, I find really gripping.

40. I usually plan out my week’s work in advance, either on paper or in my head.

41. I keep an eye open for what Professors seem to think is important and concentrate on that.

42. I’m not really interested in this course, but I have to take it for other reasons.

43. Before tackling a problem or assignment, I first try to work out what lies behind it.

44. I generally make good use of my time during the day.
45. I often have trouble in making sense of the things I have to remember.

46. I like to play around with ideas of my own even if they don’t get me very far.

47. When I finish a piece of work, I check it through to see if it really meets the requirements.

48. Often I lie awake worrying about work I think I won’t be able to do.

49. It’s important for me to be able to follow the argument, or to see the reason behind things.

50. I don’t find it at all difficult to motivate myself.

51. I like to be told precisely what to do in essays or other assignments.

52. I sometimes get ‘hooked’ on academic topics and feel I would like to keep on studying them.

C. Preferences for Different Types of Courses and Teaching

Consider each of these statements carefully, and rate them in terms of how close they are to your own way of thinking about “Different Types of Courses and Teaching.”

(1) Definitely Like
(2)
(3)
(4) Unsure
(5)
(6)
(7) Definitely Dislike

Try not to use “Unsure” unless you really have to, or if it cannot apply to you or your course.

a. Professors who tell us exactly what to put down in our notes.
b. Professors who encourage us to think for ourselves and show us how they themselves think
c. Exams that allow me to show that I’ve thought about the course material for myself.
d. Exams or tests that need only the material provided in our lecture notes.
e. Courses in which it’s made very clear just which books we have to read.
f. Courses where we’re encouraged to read around the subject a lot for ourselves.
g. Books that challenge you and provide explanations that go beyond the lectures.
h. Books that give you definite facts and information that can easily be learned.

Thank you very much for spending time completing this questionnaire.

Frequency of Mapping Index (Post Study)

• During the 16 weeks of Patho 3, how many different times did you make changes to your concept map(s)?
• Under what circumstances did you make changes to your concept map(s)?

Students make changes to their concept map(s) at various times for various reasons. How well do the following statements define your experiences of when and why you made changes to your concept map(s)?

Try not to use “Neither Agree or Disagree” unless you really have to, or if the statement cannot apply to you or your course.

(1) Strongly Agree
(2)
(3)
(4) Neither Agree or Disagree
(5)
(6)
(7) Strongly Disagree

• I made changes to my concept map just before each concept map assignment was due.
• I made changes to my concept map(s) after I watched a recorded lecture.
• I made changes to my concept map(s) after reading a journal article.
• I made changes to my concept map(s) after an Office Hours Live session.
• I made changes to my concept map(s) after taking a quiz.
• I made changes to my concept map(s) after reviewing the correct answers to a quiz.
• I made changes to my concept map(s) after submitting a workshop assignment.
• I made changes to my concept map(s) after discussing Patho 3 concepts with another student or a Professor.
• Please use this space to indicate any other times or reasons you made changes to your concept map(s). (Open-ended answer.)
Self Efficacy with Computers Index (Pre Study)

The following statements are about how people feel about using computers and learning new software. Please indicate the extent to which each statement applies to you.

Try not to use “Neither Agree or Disagree” unless you really have to, or if the statement cannot apply to you or your course.

(1) Strongly Agree
(2)
(3)
(4) Neither Agree or Disagree
(5)
(6)
(7) Strongly Disagree

- I feel very competent using computers
- I am afraid of computers.
- I can use a computer without significant difficulty.
- I avoid computers as much as possible.
- I am often worried that my academic performance in the Nontraditional PharmD is hurt because of computer problems
- I easily learn to use new computer software programs.
- I can accomplish very technical tasks on a computer.
- Learning new computer software programs is very difficult to me.
- I feel incompetent when I try to use a computer.
- I get very frustrated and feel out of control when I can’t get my computer or software to work well
- Learning to use new services available through the Internet is easy for me.
- I often have difficulty getting new software to work right on my computer
- When I run into a computer problem, I feel confident in my ability to either fix it
- I am confident in my ability to use my computer to work on the Nontraditional PharmD
Use/Experience Index (Pre Study)

• How many years have you owned a personal computer?
• How many years have you been using computers in your workplace?
• How many years have you been using computers for your education?
• Prior to the NTPD orientation, what (if any) formal computer training (classes or workshops) did you have?
• How many total months have you had access to the Internet at home?
• What type of Internet connection do you have at home (if more than one, select the fastest)?
  o 28.8 modem
  o 56.6 modem
  o ISDN
  o DSL
  o Satellite
  o Cable Modem
• On average, how many hours do you spend working on your computer (including NTPD work, business, E-mail and any other online services) in an average week?
APPENDIX B

ASSIST\textsuperscript{73} SCORING KEY

A. What is learning? – Conceptions of Learning

This index seeks to determine the student’s conceptions of learning as either “learning as reproducing” or “learning as transforming” (Marton & Salvo, 1997; Hattie et al., 1996). The first three items combined indicate “learning as reproducing.” The last four items cover a view of learning involving personal understanding and development indicating, “learning as transforming.”

f. Getting on with the things you’ve got to do.
c. Building up knowledge by acquiring facts and information.
a. Making sure you remember things well.
d. Being able to use the information you’ve acquired.
e. Understanding new material for yourself.
g. Seeing things in a different and more meaningful way.
b. Developing as a person.

B. Approaches to Learning

Students respond to items on a one to seven scale (one is high). Index scores\textsuperscript{74} are formed by adding together the responses on the items in that index. Scores on the three main approaches (i.e., deep, strategic and surface) are created by adding together the index scores that contribute to each approach.

\textsuperscript{73} The threat of social desirability to the ASSIST has been addressed by mixing the item inventory with positive and negative statements. The researcher also gave the inventory in a context where faculty members who assess the students could not see the students’ responses.

\textsuperscript{74} Entwistle (2000) suggested the first three indices in each approach (i.e., deep, strategic and surface) are consistently related to each other and can be combined with confidence. Subsequent indices, however, are more likely to vary in their relationships across different samples. Relationships thus need to be checked in the particular sample used for the study.
Deep Approach

Seeking meaning.

4. I usually set out to understand for myself the meaning of what we have to learn.

17. When I read an article or book, I try to find out for myself exactly what the author means.

30. When I am reading, I stop from time to time to reflect on what I am trying to learn from it.

43. Before tackling a problem or assignment, I first try to work out what lies behind it.

Relating ideas.

11. I try to relate ideas I come across to those in other topics or other courses whenever possible.

21. When I’m working on a new topic, I try to see in my own mind how all the ideas fit together.

33. Ideas in course books or articles often set me off on long chains of thought of my own.

46. I like to play around with ideas of my own even if they don’t get me very far.

Use of evidence.

9. I look at the evidence carefully and try to reach my own conclusion about what I’m studying.

23. Often I find myself questioning things I hear in lectures or read in books.

36. When I read, I examine the details carefully to see how they fit in with what’s being said.

49. It’s important for me to be able to follow the argument, or to see the reason behind things.
Interest in ideas (related index).

13. Regularly I find myself thinking about ideas from lectures when I’m doing other things.

26. I find that studying academic topics can be quite exciting at times.

39. Some of the ideas I come across in NTPD courses, I find really gripping.

52. I sometimes get ‘hooked’ on academic topics and feel I would like to keep on studying them.

Strategic Approach

Organized studying.

1. I manage to find conditions for studying which allow me to get on with my work easily.

14. I think I’m quite systematic and organized when it comes to reviewing for exams.

27. I’m good at following up some of the reading suggested by Professors.

40. I usually plan out my week’s work in advance, either on paper or in my head.

Time management.

5. I organize my study time carefully to make the best use of it.

18. I’m pretty good at getting down to work whenever I need to.

31. I work steadily through the term or semester, rather than leave it all until the last minute.

44. I generally make good use of my time during the day.

Alertness to assessment demands.

2. When working on an assignment, I’m keeping in mind how best to impress the Professor.
15. I look carefully at Professors’ comments on my course work to see how to get higher grades next time.

28. I keep in mind who is going to grade an assignment and what they’re likely to be looking for.

41. I keep an eye open for what Professors seem to think is important and concentrate on that.

**Achieving (related index).**

10. It’s important for me to feel that I’m doing as well as I really can on the courses here.

24. I feel that I’m making good progress, and this helps me put more effort into the work.

37. I put a lot of effort into studying because I’m determined to do well.

50. I don’t find it at all difficult to motivate myself.

**Monitoring effectiveness (related index).**

7. I go over the work I’ve done carefully to check the reasoning and that it makes sense.

20. I think about what I want to get out of this course to keep my studying well focused.

34. Before starting work on an assignment or exam question, I think first how best to tackle it.

47. When I finish a piece of work, I check it through to see if it really meets the requirements.

**Surface Approach**

**Lack of purpose.**

3. Often I find myself wondering whether the work I am doing here is really worthwhile.

16. There’s not much in my NTPD courses that I find interesting or relevant.
29. When I look back, I sometimes wonder why I ever decided to come here.

42. I’m not really interested in this course, but I have to take it for other reasons.

**Unrelated memorizing.**

6. I find I have to concentrate on just memorizing a good deal of what I have to learn.

19. Much of what I’m studying makes little sense: it’s like unrelated bits and pieces.

32. I’m not really sure what’s important in lectures so I try to get down all I can.

45. I often have trouble in making sense of the things I have to remember.

**Syllabus-boundness.**

12. I tend to read very little beyond what is actually required to pass.

25. I concentrate on learning just those bits of information I have to know to pass.

38. I gear my studying closely to just what seems to be required for assignments and exams.

51. I like to be told precisely what to do in essays or other assignments.

**Fear of failure (related index).**

8. Often I feel I’m drowning in the sheer amount of material we have to cope with.

22. I often worry about whether I’ll ever be able to cope with the course work properly.

35. I often seem to panic if I get behind with my work.

48. Often I lie awake worrying about work I think I won’t be able to do.
C. Preferences for Different Types of Courses and Teaching

These indices are scored as the sum of the four items.

**Encourages understanding (related to a deep approach).**

b. - Professors who encourage us to think for ourselves and show us how they themselves think

c. - Exams that allow me to show that I’ve thought about the course material for myself.

f. - Courses where we’re encouraged to read around the subject a lot for ourselves.

g. - Books that challenge you and provide explanations that go beyond the lectures.

**Transmitting information (related to a surface approach).**

a. - Professors who tell us exactly what to put down in our notes.

d. - Exams or tests that need only the material provided in our lecture notes.

e. - Courses in which it’s made very clear just which books we have to read.

h. - Books that give you definite facts and information that can easily be learned.
APPENDIX C

POST STUDY INTERVIEW INSTRUMENT AND SUMMARY DATA

For each of the following post study interview questions, typical responses are provided. The reader may also click on the question to hear students’ responses to each interview question.

Questions about concept mapping.

1. What is your overall assessment of your experience using concept mapping in Patho 3?
   - Liked it; knew my notes better; nice to see everything organized; helped me put things together; helped me to organize my thoughts; road map of what I needed to learn for each workshop. (seven responses).
   - Helpful to put it all together; going to back to the subjects for review; used a lot for the final exam. (three responses).
   - It was a pain; an extra burden; the tool would be great for K-12, not for college; second time through for me as I already have the outlines for the lectures. (three responses).
   - Enjoyed it; able to see how others viewed the same concepts. (two responses).
   - I was not in favor of mapping. I was asked to use it to organize my notes; this is not the way I learn; I am a linear student. (two responses).
   - Fun, but time consuming. (two responses).
   - Did not use it to study; but it helped me remember pieces of information. (one response).
   - Really interesting; not just outlining, adding relationships. (one response).
   - It started as more of a hindrance, but felt good later on; became a useful tool. (one response).
   - Did it every day; not a lot of collaboration; did not use it to its full potential. (one response).
o Liked using it; had an “ah-ha” moment in the seizure portion of the course.

o Did not use it much; only for assignments; not as much as I should have.

o Interesting tool; easy to flow chart; added a new dimension to learning.

o Really have to know the concepts before making a map.

2. **How difficult was it to learn how to use the concept mapping software?**
   - Easy to use (19 responses).
   - Initially had a problem with the CMap-Exp server (two responses).
   - I have a fear of computers and it was still easy to use (two responses).
   - Before the NTPD, I would have been lost; since the NTPD it was very easy; good instructions on Concept Mapping CD.
   - Took a while; I’m slow with computers.
   - I was not using it correctly; not easy to use.

3. **Where were you when you worked on your concept maps?**
   - All 26 students worked on their concept maps at home.

4. **Who were you working with when you worked on your concept maps?**
   - Alone (24 responses).
   - Alone, but looked at others’ maps while I built mine.
   - Mostly alone, but with group sometimes.

5. **On average, how long did it take you to sit down and make changes to your concept maps?**
   - New Map:
     - One to two hours (five responses).
     - 30 minutes to one hour (four responses).
     - Four hours
   - Changes:
     - 30 minutes to one hour (10 responses).
     - Five to twenty minutes (eight responses).
     - Never made any changes to existing maps (two responses).
     - Rarely made changes; just additions; did not delete (two responses).

6. **Under what circumstances did you use your concept maps during Patho 3?**
   - Studying for quizzes; used them during quizzes (seven responses).
   - For concept map assignments only (six responses).
   - Studying for workshops (five responses).
   - Going back to review subjects as they built on each other (four responses).
Did not use at all after creating them (three responses).
Reviewed before quiz with first map; not so much later on (two responses).
When I finished a topic; reviewed my map to understand the topic; to tie all of the concepts together; a synthesis (two responses).
Only when listening to lectures; as a way to take notes (two responses).
Studying for final exam.
Template of information for the main topics.

7. When did you use other students’ concept maps during Patho 3?
To review before all of the workshop; to “see” who others were thinking (five responses).
When I started my maps (five responses).
Did not look at others’ maps (five responses).
Looked at them for style; not content (three responses).
Looking for content more than structure (two responses).
Looked at others’ maps when I updated my map (two responses).
When I was short on time; hit the highlights (two responses).
Before quizzes; looking for gaps in my understanding (two responses).
Looking for good parsimonious points.
Always looked at everyone else’s maps; to see if they did something different.
Used them as a guide for when the subject matter was complicated.
Did not, I looked at the instructor’s maps.
Case maps with my group.

8. Did you construct a single concept map and make changes to it throughout the semester or did you construct multiple concept maps?
Separate (i.e., multiple maps) (18 responses).
Same (i.e., single map) (eight responses).

9. Why?
Separate
- To keep my maps more organized (seven responses).
  - so I could name my maps according to the workshops (four responses).
  - to make better use of space and avoid clutter (three responses).
  - wanted to print my map and have it on one page (three responses).
  - screen too small to accommodate big maps (two responses).
o didn’t want to have my maps spill over one screen.
o too much information got in the way; I wanted my maps to look pretty.
o my eyes were strained on the big maps.
• Difficult to link all of the concepts together on a single map (three responses).
• Smaller maps were more useful to me (two responses).
• So I could retrieve information from my maps; difficult to do so on a single map that is over one screen in size.
• I was afraid I would screw up a single large map.
• I did not think the material was connected.

• Same
  • So I could draw lines between different topics (three responses).
    o Wanted all of my subjects linked together to show how different drugs were linked (two responses).
  • Was easier to create a single map.
  • Did not use the single map to study; used it to see connections, to look at it in detail.

10. How did you use line and text colors, font size, bold and/or italics in your concept maps?
 o I color used for each topic; to differentiate concepts on my maps (12 responses).
o Did not use (four responses).
  • Time constraints.
  • Spent energy focusing on concepts and links.
o Different colors had different meanings on my maps (three responses).
    o Red = do not do; green = good; yellow = caution.
o Italics to emphasize points (three responses).
o Disease states used larger, bold letters in the middle of the screen (three responses).
o Had difficulty using style in my concept maps (two responses).
o To make my maps look pretty (two responses).
o Used to make the maps easier to read (two responses).
  • So I can “gulp it in better.”
o Grouped concepts based on similarity.

11. What problems did you have using concept mapping in Patho 3?
o Trouble with the CMap-Exp server (four responses).
o Hard to use the style / formatting features (three responses).
o No problems (two responses).
Accidentally deleted my maps (two responses).
Trouble linking concepts I wanted to connect (two responses).
Frustrating that the tool was not as easy to use as Word.
Trouble printing others’ maps.
Could not visualize the entire page; needed more screen space.
My maps became too complicated.
Too little time.
Could not use cut and paste.
Using curved lines at first.

12. What was your best experience using concept mapping in Patho 3?
- Became easier to use over time (seven responses).
- Saved and summarized all of my information (five responses).
- Great feeling when I completed a map; it looked good and I learned a lot (two responses).
- Conceptually, I could see how I would use the map as a clinical pathway; as a treatment algorithm (two responses).
- My first map; I put so much time into it when I thought it would be graded for content (two responses).
- Helped to put together my group’s workshop.
- External storage of maps on the CMap-Exp server.
- Liked using colors.
- Finding new connections on my maps.
- Streamline approach to topic; forced me to be precise and succinct.
- Found where I had gaps in my understanding; found out really how much I had learned.

13. What was your worst experience using concept mapping in Patho 3?
- Too little time; mapping just another thing I have to do (six responses).
  - Doing them last minute to turn them in for an assignment.
- Building my first map; took a while to figure out (five responses).
- I lost updates I made to my map (five responses).
- All four maps seemed to be “on top of each other;” ran out of room (three responses).
- Hate to type; an import feature would be great.
- Terrible for note taking.
- Took 45 minutes the first time I tried to save it to the CMap server.
- My classmates did not want to work on mapping together.
- Could not get my map to center and print.

14. Tell me what thinking process you went through to create your first concept map?
- Used an outline from the lecture notes (12 responses).
• Filled in outline with information from book.
  o Divide and conquer; divided out the concepts, categories and themes so it was less overwhelming (six responses).
  o Looked at others’ maps (four responses).
  o Stared at the screen; what am I doing (two responses)?
  o Impressions were “fuzzy” in my mind, so I sketched my map out on paper first (two responses).
  o Tired to be creative, clear and concise; just the main points and the relevant issues (two responses).
  o Listened to all the CD tutorials; planned the map in my mind and started mapping; it just grew; it was an organic process.
  o Created a sample map like in the tutorials.
  o Played and experimented.

15. Tell me about your thinking as you made changes to your concept maps throughout Patho 3?
  o If I learned something new or developed a better understanding of a concepts (six responses).
  o Did not make many changes to existing maps (six responses).
  o If I missed something in a lecture (five responses).
  o If I learned something new in a workshop (five responses).
    • In preparing for a workshop.
  o After reviewing others’ concept maps (three responses).
  o To create new connections between disease states.
  o Read an article; went back and added concepts to my map.
  o Wanted to make it look better for the grade.
  o To reformat my existing maps.
  o After taking a quiz.

16. Did you find concept mapping useful in helping you to visualize how your understandings of Patho 3 concepts and conceptual relations changed over the semester?
  o Yes (general) (five responses).
  o Overall review of disease states; broad swipes; skeleton; road map (three responses).
  o Helped me remember; mapping was the “most wonderful thing.”
  o For a brief overview of treatment strategies.
  o Good note-taking tool.
  o Forced me to generalize and categorize; made me think broadly and see connections between concepts.
  o Early maps, no; but later maps were very helpful; I should have created one big map.
• No
  • No (general) (four responses).
  • Separate maps might have kept me more organized; needed an outline format (two responses).
  • Not enough time.
  • I felt I had a good understanding of each topic.
  • Patho three disease states are not really linked; better to do with cardiology where there is more synthesis.
  • Second time through the material.
  • I do not use visual graphics for Pharmacy content.
  • Did not refer back to maps to see how things changed.
  • I never went back to my old maps.
  • I am an auditory student, not a visual student; so mapping did not help me learn.
  • Would be good for someone without good study skills; we are advanced students and already have good note-taking skills.

17. Do you think your concept maps, at the end of the Patho 3 course, are a fair representation of how you understand the key concepts and conceptual relations in Patho 3?
  o Yes
    • Yes (general) (seven responses).
    • Yes, but I could have put in more details (seven responses).
    • Good summary of what I know (five responses).
    • Yes, but I needed more time (four responses).
  o No
    • No (general) (two responses).
    • Could not fit everything into my maps.
    • Concepts are so deep, one semester was not enough time to use concept mapping really well.

18. Under what circumstances did you change the hierarchical structure of your concept maps or reorganize where major concepts were situated on your concept maps?
  o Did:
    • My ideas changed when I looked at others’ maps (three responses).
    • When I made additions to my maps, I found that I had to move concepts around (two responses).
    • Did (general).
    • When my map felt cluttered.
• Manipulated the map into different shapes so I could print it.
• When I found a new connection, I would rearrange concepts.
• To prioritize major concepts; moved those items up in the hierarchy.

  o Did Not:
  • Did not (general) (11 responses).
  • No, tried to have the same hierarchy in each map.
  • Did not change key elements much; sometimes chose not to include major concepts.
  • Wanted to, but I did not know how to do it.
  • I made separate maps.

19. Under what circumstances did you simply add new concepts or conceptual links to your concept maps?

(Note: Most students had already addressed this concept in question #15.)

  o After reviewing new topics and readings (two responses).
  o After taking quizzes.
  o After looking at others’ maps.
  o After reviewing ideas with my group members.

20. Did working with your concept maps help you see where you had gaps in your understanding of Patho 3 concepts?

  o Yes (15 responses).
  o No
  • No (general) (five responses).
  • No, mapping may be helpful for someone for whom the content is new; it was not new for me
  • Not from looking at my maps, but yes when looking at others’ maps.
  • No, maps were just basic principles.
  • No, maps just helped refresh me and help me to tie it all together.
  • No, others’ maps were too hard to follow; too busy.
  • Not too many gaps in my maps; I was already 80% there.

21. What did you do when you thought you were missing a key concept or conceptual relation on your concept maps?

  o Reviewed lectures, textbooks and notes (seven responses).
    • Would have missed this information without concept mapping.
Looked at others’ maps and added their ideas to my map (six responses).
I changed my maps after reviewing the new information; went back and added the treatment strategies to my maps (three responses).
Ask questions in a workshop.
Made me think about relationships in each topic.

22. Which of your four concept maps is the most meaningful to you? Why?
First map; I put the most amount of time into it; learned how to map (12 responses).
  • Thought it would be graded for content.
Fourth map; most complete, has all of the disease states on it (nine responses).
  • Most familiar with concept mapping; allowed me to be short and concise (two responses).
All were meaningful; all taught me something (three responses).
Third map; topics started linking together.

23. What recommendations would you give the second and third classes of NTPD students as they learn to use concept mapping?
Keep your maps simple (five responses).
Allow for more time to map; do not wait until the last minute. (five responses).
More you use it; the easier it gets, start early (three responses).
Start with the Pharmacokinetics course, then use in Patho one through six (three responses).
Make mapping part of your regular study skills; use mapping as a learning device (three responses).
Do not be overwhelmed; it is easy and fun to use (two responses).
Be patient and relaxed; use your own interpretations; this is supposed to be your thought processes (two responses).
Learn to use it as a team; build team maps (two responses).
Look at others’ maps (two responses).
Make notes as you view the lectures.
Make multiple maps; one map is “too much baggage to carry throughout the semester.”
It depends on their learning style; I recommend listening for key concepts and then organizing the concepts on their map.
Do not introduce the tool during the summer.
Have the right attitude- not just to “get it done.”
Think of it as an organizational tool.
Move concepts around; change your maps.
Questions about collaborative learning.

24. What aspects of collaborative learning do you find *beneficial* to your learning?
   - Hear others’ perspectives; multiple views and opinions; lots of pieces in the health care puzzle (15 responses).
   - Distributed expertise; everyone is good at something; work in different areas of Pharmacy, and we share our ideas (11 responses).
   - Division of labor; helps to get projects done more efficiently (six responses).
   - Have to learn more to argue your point (two responses).
   - Forces me to get my work done by the group deadline; better time management (two responses).
   - Check my ideas against the group before I turn in an assignment for a grade.
   - I am a verbal student; live audio internet collaboration works well.

25. What aspects of collaborative learning do you find *harmful* to your learning?
   - Some group members do not contribute equally (nine responses).
     - Tough to tell someone they are not “pulling their own weight;” bad feelings are often the result (four responses).
     - But that can also be a good education; that is life.
   - Hard to coordinate schedules of group members (four responses).
   - You are out of the loop when your computer shuts down (three responses).
   - Hard to consolidate group ideas and gain a consensus for a group workshop submission (three responses).
     - Multiple views; not sure which one is correct; spend lots of time debating.
   - Temporary groups were a “pain;” former leaders were perturbed if they were not assigned as the temporary group’s leader (two responses).
   - If someone has “misguided expertise;” it is a disadvantage; others’ ideas can complicate or cloud my “clear understandings” (two responses).
   - In my first group, several people dropped out of the program; participation was low.
   - Frustrating when the leader of my group does not acknowledge my ideas.
26. How useful did you find concept maps in sharing your ideas with other students in the class?
   - I did not share my map (15 responses).
   - Not sure if anyone else was looking at my map (three responses).
   - Useful to see each others’ maps (two responses).
   - Difficult to share; topics are pretty “black and white;” just sharing facts; same content that everyone else already had (two responses).
   - Talked about the first map with someone else; then split off and did my own map.
   - “Hard” workers wanted to review my map and I wanted to review their maps.

27. How did concept mapping affect your communication with other students in Patho 3?
   - No effect on communication (20 responses).
   - Talked about using maps for workshops (three responses).
   - Yes, increased communication inside and outside my group (two responses).
   - Did not talk directly to other groups; but I did review their maps, which is more communication than I had with them before.
   - Increased communication; everyone complained about another project.

28. What did you do when you thought you understood how multiple concepts fit together on your concept map and then reviewed someone else’s concept map that had a different view?
   - See next question for typical responses.

29. Did you change your map to match the concept map you reviewed?
   - Left my map unchanged (six responses).
   - I would make changes to make my map correct (four responses).
   - I made the best of both worlds; I took the best pieces from others’ maps (four responses).
   - I would have made changes, but I never came across any maps that I liked better than my own (three responses).
   - My maps were like others’ maps so I made no changes (two responses).
   - I would study others’ maps to determine “where they were coming from;” but made no changes to my map (two responses).
   - There were not a lot of different views; however a few times I said “a-ha;” I am open-minded.
   - I would go back and review the subject.
   - Changed the layout of my map based on others’ map styles.
Check others’ maps to see how I could construct future maps; but did not make changes to my current maps.

One other student and I would review each others’ maps; we are friends so criticism is OK; I would add her concepts to my map.

Everyone mapped differently; it was like looking at their thought processes which made it very confusing.

30. Did reviewing other students’ concept maps help you learn new NTPD information better than before you used concept mapping?

Yes

- Yes (general) (five responses).
- Others students had different ideas than I did (five responses).
- Kept me on top of things; made me prepare.
- Building maps was like studying.
- Before maps; it was hard to tell others’ thought processes; hard to see where they were coming from.
- Could see other groups’ understandings.
- Concept maps are like diagrams or algorithms.
- It was like reviewing someone’s notes.

No

- No (general) (six responses).
- Should have reviewed more maps; lack of time (four responses).
- Already know how I learn; good tool for Pharmacokinetics.
- More useful if professors built better maps.
- No, I had no trouble learning before concept mapping.

31. There was a trend for students not to ask other students or professors to review their concept maps. What do you make of this trend?

Time constraints (10 responses).

- Seemed presumptuous to ask someone else to take time to review my map when we are all short on time (two responses).
- Maps done just before the assignment deadline; no time to share.
- We focused on the main assignments in the course.

Pride; not everyone wants constructive criticism; experienced Pharmacists think they have a good handle on things (two responses).

- Sharing your maps is like “being on a stage and being critiqued.”

We become individual students (vs. collaborative) at a certain age (three responses).
- Everyone learns differently; I am not sure how looking at others’ concept maps will help me.
  - Maps were not graded for content (two responses).
    - Total point value for concept maps was low; therefore maps were not perceived as being important.
  - Sharing was not required, so no one did it (two responses).
  - New tool; not used to it yet (two responses).
  - Maps are already available on the CMap-Exp server; did not make an additional effort to share (two responses).
  - Subject matter was straightforward; we all have similar understandings due to similar lectures, resources.
    - Maps are just an outline of the coursework.
    - Others’ maps did not have any “earth shattering discoveries.”
  - Do not know students outside of our groups very well; not a close community.
    - Would only ask someone I knew well and respected in my group.
  - Why should someone else get a “free ride” off of my work?
  - Sharing seems like cheating.
  - I did not think my maps were all that good.
  - We needed more instruction on how to share our maps.
  - Sharing not perceived as being beneficial to my learning.
  - Others’ maps were not clear and it was hard to follow their thoughts.

32. When you asked someone to review your concept map, were you more likely to ask:
   a. a student in your group?
   b. a student in a different group?
   c. or an NTPD professor?

   - Did not ask anyone to review my maps (17 responses).
     - Will not pester someone unless I need help.
   - I shared with a student in my group (five responses).
     - I asked our group to review a workshop map; not one of my personal maps.
     - Group members are all close friends; I trust their opinion.
   - Sharing my maps with my professor did not occur to me (two responses).
   - I shared my first two maps with my professor.
   - Showed maps to a friend at work.
33. What, in your opinion, might have been done in Patho 3 to encourage more collaborative sharing of student and professor concept maps?
   o Make it an assignment (with a high point value) to share maps with other students; to critique others’ concept maps; to create group maps (ten responses).
   o Use maps in workshops; share good maps as exemplars (six responses).
      • Stop using SOAPs; replace them with concept maps for the workshops.
   o Provide more time for concept mapping (four responses).
   o Have professors create better maps (three responses).
   o Online chat session to discuss how to share maps (two responses).
   o Orient students to share maps from the beginning; NTPD orientation.
   o Have professors review maps.
   o Provide incentive for sharing; carrot instead of a stick; e.g., win reference text or extra credit.
   o The maps did not “mean” anything because they were not scored for content.
   o Need multiple semesters to concept map; program should allow us to continue to map and provide technical and instructional support.
   o It is up to the individual.

Questions about students’ self efficacy with computer technologies.

34. What experiences have you had with computer technologies (hardware or software) that helped or confused you as you tried to learn to use the concept mapping software?
   o Had computers for multiple years; very easy to learn mapping software (five responses).
   o Frustrating for me when things go wrong (three responses).
   o Bad at learning new computer technologies (two responses).
   o Understand the client-server relationship.
   o Little computer experience; confused by mapping software at first.
   o I have an MBA in information systems; I was well prepared for NTPD technologies.
   o Use a program that orders drugs for patients at work.
   o I am a trial and error student; I can figure out the limits of a program quickly.
35. What experiences did you have with computer technologies (hardware or software) prior to Patho 3 that helped you construct and share your concept maps?
   - Have created Power Points; similar to concept mapping (five responses).
   - Lots of experience with Word (four responses).
   - Adobe Photo Deluxe; Publisher; pallets in photo programs (three responses).
   - Submitting assignments with file attachments (two responses).
   - Flow charting software (two responses).
   - Familiar with “gif” files.
   - Have built web pages.
   - Diabetes diagram was similar to mapping.
   - Point and click GUI interface.
   - Good typing skills.
   - I needed a cut and past feature; I had to retype my lecture notes.

36. After using concept mapping software, do you feel you are better equipped to learn and use new computer technologies?
   - Yes
     - Yes (general) (13 responses).
     - More computer experience makes it easier to learn new software (eight responses).
     - It helped me to learn how to save to different drives.
   - No effect (four responses).

Questions about the “complexity vs. parsimony” dilemma.

37. Did you discover you were able to eliminate concepts and conceptual relations from your concept map as you learned more and developed a more sophisticated understanding of Patho 3 concepts?
   - Yes (17 responses).
   - No; I only added concepts and links; I was afraid to try (nine responses).

38. What do you make of this phenomenon?
   - Getting rid of the frivolous information and clutter (seven responses).
   - Maps were a changing framework and changed as my thought processes changed (four responses).
   - Consolidated my maps to “streamline” them (three responses).
o Sometimes I deleted concepts I deemed not to be as important (two responses).
o Once I understood something, I no longer needed to show it on my map (two responses).
o Some details were overkill; smaller maps made it easier to visualize important ideas.
o Beneficial to tie things together after adding a new concept.

General questions.
39. What is your overall assessment of your experience with Pathophysiology and Therapeutics III?
   o Good (general) (18 responses).
o Good, same as other Patho courses (four responses).
o Not as organized as the other Patho courses.
o I learned a lot; psychiatric is not common in retail Pharmacy.
o This was my most difficult semester; personal distractions.
o Hard to learn in the summer; would rather be outside.
o Changing groups was difficult.
o Didn’t like a lot about the course; scheduling was off.

40. What value do you place on being a member of the 1st NTPD class?
   o Our class started the program; we are pioneers and I am proud to be involved (20 responses).
o Proud to be back at Ohio State (four responses).
o Only way I could get my PharmD (two responses).
o We are “guinea pigs;” NTPD team learns from our experiences (two responses).
o Lots of work, but it is worth it; It is an accomplishment (two responses).
o Nervous at first, but proud I worked hard to learn all of the necessary technologies.
o I feel part of a community.
o Experimenting all the time; we are helping to mold the program.
o Use what I learn at work.

41. Do you have any additional comments on your experiences using concept mapping?
o I am not a visual student; was hard for me to use maps in my studying (two responses).
o Tutorials were very detailed; very helpful.
o Interesting to experiment with a new learning technique.
o Grade for content next time.
o The professor’s maps were not good and therefore not helpful.
Mapping was a valuable tool, but it should be introduced earlier in the NTPD program.

Mapping is a good idea for new subjects; not as beneficial for when the curriculum is review.
APPENDIX D

PRE AND POST SURVEY OPEN RESPONSES DATA

Pre Survey Responses

If there is anything else you would like to say, please do so in this space.

• I really learn when all the facts are presented in the lectures. I like to think for myself to solve a problem, although I cannot really deal with extremely analytical concepts.

• Often time constraints (we are, after all, all currently employed full time as well as doing this program) drive the amount of info that we can ingest!

• The question on what we like to be tested on and how much do we like to read extra ourselves is somewhat unfair. There are topics that I really like and want to learn more because they interest me. There are other topics where I just want to make it through the basic material, and want spoon fed.. tell me what are the important facts. It just depends on the topic. Generally the topics that interest us will also be the ones that we can use, or would like to use in our work environment.

• Would definitely say that most of my difficulty arises with time constraints, difficulty with organization (both the course and my time), and to lack of concrete direction in the course. I like things to be concise, to the point, and NOT frilly. Just tell me what I need to know, give me the tools to learn it and explore it in detail on my own (or give me the important details), and I am happy

• At times, it has been difficult to determine what the person grading an assignment expects. Although learning is the main goal, it is rewarding to receive a good grade when time and effort is put into an assignment. It is difficult to receive a good grade if you are unsure of the grader's expectations. Expectations seem to be more clear as we progress in the program - maybe the unclear expectations are to be expected since we are the
"pioneers" in this program. Another general comment regarding the program is the group assignments and subsequent group grades. Division of work is not necessarily equal but the resulting grade is - good or bad. I see some benefits in group assignments, especially if everyone in the group contributes. However, I think it would be beneficial to change group membership on a regular basis - every trimester, every other trimester, etc. This would allow us to work more closely with all of our classmates.

- There is a lot of material and it is difficult to cover it all.

- I feel that some of my answers may be contradictory. I would like to make some comments on this point. As a student, I like to succeed (and get an A), so sometimes knowing how to get an A makes my life a lot easier. Therefore, of course I like instructors who make it obvious what is important for exam questions. On the other hand, I am a professional and have been practicing "without a net" for 16 years and I know that there is NOT really a "right" answer much of the time. I would enjoy the ability to think on my own more often, and would enjoy the chance to be judged for my understanding of the data which has been provided, and my professional judgment of what is prudent and worth the risk : benefit ratio. Sometimes I feel that following my professors "way" of doing things will earn me a better grade.

- Some of my answers lean toward having clear choices of references, easy-to-learn notes, and not reading a lot of the suggested readings per our professors have more to do with the time constraints of trying to work a full-time job + manage a household in addition to our schoolwork than with a lack of interest in exploring what we're studying in a greater depth. Although we may not be able to get to all of the additional suggested readings, I think those of us who are particularly interested in that topic really appreciate the references. There are many areas that we've covered that I would like to revisit in greater detail in order to further my abilities. The more you learn, the more you realize you don't know!

- I have a comment on questions relating to additional studying, reading, etc., questions such as: "Courses where we’re encouraged to read around the subject a lot for ourselves." Yes, I would LOVE to do additional reading and/or research. However this class has used up my most valuable commodity = TIME!

- I like exams or projects that encourage you to use your creativity. I don't like T/F exams of any kind because they focus on tricks. I like problem solving and case studies especially when there are multiple approaches. I like to be able to explain the logic behind the decisions. I like application of the material and how to find information over any sort of rote memorization. I
like interactive learning like the workshops. I like sharing experiences. I
definitely don't like questions designed to trip up students with incomplete
questions or out of date facts. I am more interested in the process of learning
than the facts learned. Thanks for taking the time to introduce new
approaches to learning.

• Quite often our enthusiasm about going beyond what is required is dampened
  by the shortage of time and the volume of study material.

• I really like learning in groups and sharing information

• I appreciate professors who encourage self motivation and self exploration of
  ideas, however, this is not a gradeless system where we are rated on our
  personal development. Bottom line: whether we want to or not, we have to
  look for ways to impress the professor or try to figure out what they view as
  important in order to achieve the best grade. We can voice our interests in the
  lecture/workshop setting but are still limited to the instructors emphasis for
  grade/performance purposes.

Post Survey Responses

Students provided the following reasons for why they most often asked students
within their group75 to review their concept maps:

• I know them better than any other group (two similar responses)
• We, as a group, turned in a concept map to augment one of our workshops.
• I asked my group members to work together on the maps, so that we could
  address the issues raised in our workshops (two similar responses)
• I asked my group members to review it because it was convenient to
  communicate with them during OfficeHoursLive®
• I was more likely to ask the members of my group with whom I work closely
  with on a regular basis.

75 It is worth noting students’ gave no reasons for sharing their concept map(s) outside of their
groups or with their professor(s).
Comments by students who most often reviewed concept maps from their group:

- My group was group one. We always have a way of working together as a team. We always appreciate each other's opinion.
- My group, probably because I know them, and I know their strongest past and weakest part.
- I most often looked at maps of students within my own group because I know them the best and understand their intelligence level, enabling me to compare my understanding with theirs. Also, by looking at their map, I could talk to them about it if needed in a chat session.
- Because we had discussed the concept maps, I most often reviewed those of my work groups.
- Within the group, can probably discuss during chat session.
- I looked at one student's concept maps consistently because I trust her work and know she puts 100% into her work!
- Because we discussed the mapping among the group members and I wanted to see how I was doing in comparison to their work.
- Reviewed concept maps of fellow group members to see if anyone needed help.
- I liked to review two of my group members maps, because one is always simplified and generalized on topics and other is always in detailed form.

Comments by students who most often reviewed concept maps from both internal and external groups:

- To check my understanding of the material and see if there were concepts I missed.
- I reviewed others concept maps to see what everyone thought was important.
- I randomly reviewed those that had theirs done to see if I was doing it correctly. Also, some individuals are very work detail specific. This is why I chose to review theirs to make sure I didn't forget anything important.
- To gain insight about course topics.
- Equal outside my group and inside my group.
- Because I worked with these students and I understand how they view ideas.
- Wanted to sure if my concept was right; comfort level.
- I was interested to see how others organized their thoughts, as well as the importance that they placed on readings vs. lectures vs. text book in their understanding of the material.
- I reviewed the concept maps created by my group as well as other groups equally. The reason was to get a balanced view.
• I wanted to get an idea of what others were thinking and different ideas about layout.
• I believe that I was more likely to review concept maps of classmates who I know and respect.

Comments by students who most often reviewed concept maps from their professors:

• I trusted that the instructors had a good understanding of the topic and that their maps would be most helpful to review.
• I was interested also to see what the professors thought was important professors, to get a feel for the first one.

Two students noted why they did not review professors’ concept maps:

• I think the reason why I didn't review the professors' maps as often is that I remember them being available toward the end of a subject and the impending coursework for the next subject seemed to need immediate attention. I will definitely use their maps as a review prior to the final.
• I never looked at the professor's because I never had time to do so.

Frequency of Mapping

Students reported two distinct categories of reasons the researcher had not anticipated: (1) general discovery of new information (including fixing “mistakes”) and (2) striving to create parsimonious, aesthetically pleasing concept maps.

Discovered other new information:

• If I learned a new concept that was not previously added to my map, I would make changes (nine other similar responses)
• Usually added something that I missed. (two other similar responses)
• After doing some continuing education about the subject; after learning more at my workplace
• I started a map and returned the next day to finish it. I had made a mistake and corrected the mistake
• Whenever I got a new understanding or new connection between topics or when moving on to new information
Seeking parsimonious and/or visual aesthetic concept maps:

- Looked at some of the other student's maps and decided that I could make the graphics fancier and that certain pieces of information should be included. If time permitted, I'm sure I would have gone back and made more changes during the semester (two other similar responses)
- I made changes when I wanted to make it a concept easier/simpler to understand (one other similar response)
- To make it more visually perfect
- To re-word / re-arrange the info already presented. To make it more presentable (style wise)

What was your overall impression of concept mapping?

Time Limitations:

- I thought the concept was very good. I did get a better understanding of the material from doing them. I thought they were fun...although time consuming.
- it was just sometimes a time crunch to get them, the readings, lectures and quizzes done simultaneously.
- I enjoyed concept mapping and learned a lot from the other students through concept mapping. My only concern was the time it took me to build my concept map, and at times I felt I could have done a better job if I had more time.
- I see a use in the future for Concept Mapping, such as when I may be making a presentation to nurses and/or fellow pharmacists. However unfortunately for most students it was another task that took up precious time, especially during the summer.
- the concept of these maps was excellent. they really do help. I just could not invest the time nor energy that I wanted to in order to explore all the avenues that the concept maps had to offer.

Helpful for Organizing Understandings / Studying:

- The material seemed to be more solidified in my brain by doing this...I remember things much better when I write things down. This was very similar
- I found the concept maps helpful for studying for quizzes.
• Cable - I intend to use this concept mapping as a means of summarizing my entire didactic program. I enjoy making the maps because I have always learned through repetition and memorization, so by constructing a map and reviewing the material as I do so, it has only helped me with each topic. As you noticed, I made a new map for each workshop, my goal being to have a neat, compact map/summary of each topic that I can continually refer back to over time and have a quick means of review. Perhaps I can even print them and make a booklet. I am going to make concept maps for Patho II (last winter) and possible kinetics from last summer (if I can get motivated).

• Concept mapping on Patho 3 is usually based on individual's own focus/ideas on a certain disease state and treatment. One's focus may not be the same as others, it can be built from lots of different angles, such as generalized or detailed on treatment or patient management. I do like to see other students maps and have some ideas from them.

• Even though concept mapping is a time consuming exercise, I found it very useful for learning purpose. It helped me to transfer the abstract ideas in to more uniform format. This in turn helped me to visualize the flow which a topic should take to make learning easier. The sharing of concept mapping via C-Map Exp server was probably the most useful feature. It allowed me to look at an issue from my colleagues'/co-students' perspective. This helped me to think out side the box.

• I am glad we still have this resource available to us as I think it will be a great study tool for the final and upon finishing this course. I would like to review all my maps at the end of this course and save them so that I can use as a reference in the future.

Brainstorming Tool:

• I enjoyed concept mapping and I think it can be a useful brainstorming tool. Online it is useful but difficult because we never know when another person will update but it is great because it is easily accessible to everyone. The concept is a good one. . .

Instructor Scaffolding:

• Making concept map(s) can be very helpful in terms of understanding the whole subject. I don't think the concept map should be the description of whole things. Concept map should be simple concise but indicate whole story. I think it could be more helpful if this concept map is provided by professor or instructor before or after the lectures rather than students. Sometimes reviewing other students'
work was more confusing because there were so many contents in there.

Extrinsically Motivated Students:

- I felt frustrated that we were not graded on content, because at this level, I feel that students are largely motivated by grades (unfortunately!, because that is NOT why most of us are here, I am sure!). I feel that if the profs spent more time on content, looked a tour content, and graded us on our organization of ideas, students would have spent more time on it.
- After I learned that we were not graded on content, I was less motivated to make my map "the best".

Concept Mapping not used to its Full Potential:

- I enjoyed the concept mapping, but had trouble engaging my team members in fully utilizing the function. They felt it was an additional function to learn, and they were not motivated to utilize it fully.

Concept Mapping not Beneficial:

- I doubt that I would ever use CMapping during normal study times or to enhance my learning. I did not feel that it was of benefit to me, it seemed to only add more work to my already oversized stack.
- I think this is a good tool for elementary and middle school children, but not for college students
- The survey should ask the perceived value of the concept mapping. Since this is not the way I learn I found it of no value
APPENDIX E

STUDY TIMELINE

Week 1:
- Students receive CDs containing:
  - IHMC CMap® concept mapping software (PC and Mac).
  - Written instructions and two instructional videos (Lotus ScreenCam®) on: (1) how to install and use the IHMC CMap® concept mapping software, (2) how to save their concept map to the public concept map server, and (3) how to save their concept map as a “gif” image.
  - Two narrated PowerPoint tutorials (Real Presenter®) on the theory and use of concept mapping and collaborative learning in online learning communities.
- Students view course syllabus and the course calendar (WebCT®) and are reminded that the four concept maps and completion of the two surveys are required assignments of the Patho III course.
  - ASSIST Learning Styles Indices
  - Self Efficacy with Computers Index
  - Use/Experience Index

Week 2:
- Two audio chat sessions (OfficeHoursLive®) on the theory and use of concept mapping and collaborative learning in online learning communities.
  - Questions on how to use the IHMC CMap® software will also be answered.
  - Students will be provided with sample concept maps both in WebCT® and in the audio chat sessions (whiteboard).
  - Discuss Consent Form One (download, sign, fax to Cable)
  - Show simple and complex concept maps
    - Show how NASA’s workgroups use concept mapping (IHMC-UWF: Mars 2001)
  - Multiple sub-maps for sub-projects
Use research in Power Points – collaborative learning / concept mapping

Emphasize: this is NOT a book or course outline! This is a conceptual map of your understandings of Patho 3. There is no one “correct” way to concept map.

Week 3:
- Students will be instructed to map their first concept map of their existing conceptual understandings of Patho 3.
- Teacher scaffolded concept map of key Patho 3 concepts provided to students.

Week 4:
- Students submit concept map #1 as an assignment.

Week 5:
- Send E-mail to all students encouraging them to share their concept maps with other students and the course teachers.
- Students will be reminded revise and add to their concept maps.

Week 6:
- Students submit concept map #2 as an assignment.

Week 7:
- Send E-mail to all students encouraging them to share their concept maps with other students and the course teachers.
- Students will be reminded revise and add to their concept map.
- Teacher scaffolded concept map of key Patho 3 concepts provided to students.

Week 8:
- Students submit concept map #3 as an assignment.

Week 9:
- Send E-mail to all students encouraging them to share their concept maps with other students and the course teachers.
- Students will be reminded revise and add to their concept map.
Week 10:

- Students submit concept map #4 as an assignment.

Week 11-14:

- Students take second survey: (Available: July 15\textsuperscript{th} – August 9\textsuperscript{th}, 2002)
  - Sharing Maps Index
  - Reviewing Maps Index
  - Reviewed from Whom Index
  - Frequency of Mapping Index

Week 15: Study Ends

- Collect Data on Final Grade

Week 16: Finals Week

Week 17: Post Study Interviews

- In-person interviews and/or online interviews in OfficeHoursLive\textsuperscript{®}.
  - Discuss Consent Form Two (sign in person, or download, sign, fax to Cable)

Week 18:

- Score concept maps (researcher and two research assistants).

Week 19:

- Analyze data and write results.
APPENDIX F

RECRUITMENT LETTER

Date

Greetings Name,

As you know, in addition to working with you in the Nontraditional PharmD (NTPD), I am a Ph.D. student at The Ohio State University. Dr. Dennis Mungall and I have discovered an educational technology called “Concept Mapping” we plan to use in all future NTPD courses. In addition to my normal duties of introducing you to this new technology and supporting its use in the NTPD, I will be studying how you use it in Pathophysiology and Therapeutics III (Patho 3) as part of my dissertation research.

The purpose of this research is to explore how visualizing your understanding of Pathophysiology and Therapeutics III affects your learning and the learning of your colleagues in online learning environments. Ultimately, the findings from this study will serve as a basis for recommendations for other online degree programs at The Ohio State University.

Phase 1: Concept Maps and Surveys

- At the beginning of Patho 3 (May 6th, 2002), I will provide you with the concept mapping software and instructions on how to install and use it. All of the materials you will need will be provided on a CD.
- I will support you as you learn to use the concept mapping software.
  - If you ever have a question or a problem, I will be available to help.
- I will also host two Office Hours Live sessions at the beginning of Patho 3 to answer your initial questions about concept mapping and describe the learning benefits of concept mapping.
- During Patho 3, you will build four (4) concept maps and complete two (2) surveys.
Phase 2: Interview

- After Patho 3 has ended (August 23rd, 2002), I will request a short 30-minute interview with you to learn more about your experiences with this new educational technology.
- I will gladly travel to meet you at any location and time that is convenient for you.

I celebrate your pioneering spirit and look forward to working with you as we continue to innovate in the NTPD. As always, your participation in helping us implement new educational technologies into the NTPD is critical to the success of our program.

Please feel free to contact me at any time with questions, suggestions, and/or concerns,

Sincerely,

Cable Green
Director of Educational Technology
Co-Investigator
E-Mail: green.180@osu.edu
Phone: 614-292-1464

Dr. Stephen Acker
Associate Professor
Director of TELR
Principal Investigator
E-mail: acker.1@osu.edu
Phone: 614-292-6026
APPENDIX G

CONSENT FOR PARTICIPATION IN RESEARCH:
SURVEY AND CONCEPT MAP DATA

Protocol # 02E0130

I consent to participating in research entitled: Visualizing Conceptual Change: The Role of Concept Mapping in Social Construction of Understandings in Online Learning Communities.

I understand I will complete four (4) concept maps as part of my regular assignment load in Pathophysiology and Therapeutics III. I also understand I will complete two surveys: the pre survey contains 88 questions which will take approximately 20 minutes to complete; and the post survey contains 36 questions which will take approximately 10 minutes to complete. I understand my participation in answering the questions in the pre survey and/or the post survey is voluntary. I give my informed consent to the researchers to use my survey and concept map data for this research.

I understand the researchers will create a fictitious first name for me (no last name will be used) when writing the results of this research. This will serve to protect the confidentiality of my responses.

Dr. Stephen Acker, Principal Investigator, or his authorized representative, Cable Green, Co-Investigator, has explained the purpose of the study, the procedures to be followed, and the expected duration of my participation. Possible benefits of the study have been described, as have alternative procedures, if such procedures are applicable and available.

I acknowledge that I have had the opportunity to obtain additional information regarding the study and that any questions I have raised have been answered to my full satisfaction. Furthermore, I understand that I am free to withdraw consent at any time and to discontinue participation in the study without prejudice to me.
Finally, I acknowledge that I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: ________________________

Signed: ________________________

(Participant)

Signed: ________________________

(Principal Investigator or his/her authorized representative)

Witness: ________________________

Please contact the researchers at any time if you have any questions or concerns about this research.

Cable Green (Co-Investigator)
Doctoral Candidate
Director of Educational Technology
College of Pharmacy
The Ohio State University
Phone: 614-292-1464
E-mail: green.180@osu.edu

Stephen Acker, Ph.D. (Principal Investigator)
Associate Professor
Director of Technology Enhanced Learning and Research
The Ohio State University
Phone: 614-292-6026
E-mail: acker.1@osu.edu
APPENDIX H

CONSENT FOR PARTICIPATION IN RESEARCH: INTERVIEW DATA

Protocol # 02E0130

I consent to participating in research entitled: Visualizing Conceptual Change: The Role of Concept Mapping in Social Construction of Understandings in Online Learning Communities.

I understand I will be interviewed by Cable Green (Co-Investigator) on my experiences using concept mapping in Pathophysiology and Therapeutics III. I understand this interview will be video-taped and/or audio-taped and will take approximately 30 minutes. I give my informed consent to the researchers to use my interview data for this research.

I understand that video and/or audio recordings of this interview will be reviewed only by the researchers in charge of the study and that my confidentiality will be protected. I understand the researchers will create a fictitious first name for me (no last name will be used) when writing the results of this research. This will serve to protect the confidentiality of my responses. After articles arising from this research have been published, the interview video and audio tapes will be destroyed.

Dr. Stephen Acker, Principal Investigator, or his authorized representative, Cable Green, Co-Investigator, has explained the purpose of the study, the procedures to be followed, and the expected duration of my participation. Possible benefits of the study have been described, as have alternative procedures, if such procedures are applicable and available.

I acknowledge that I have had the opportunity to obtain additional information regarding the study and that any questions I have raised have been answered to my full satisfaction. Furthermore, I understand that I am free to withdraw consent at any time and to discontinue participation in the study without prejudice to me.
Finally, I acknowledge that I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: ________________________
Signed: ________________________
(Participant)

Signed: ________________________
(Principal Investigator or his/her authorized representative)

Witness: ________________________

Please contact the researchers at any time if you have any questions or concerns about this research.

Cable Green (Co-Investigator)
Doctoral Candidate
Director of Educational Technology
College of Pharmacy
The Ohio State University
Phone: 614-292-1464
E-mail: green.180@osu.edu

Stephen Acker, Ph.D. (Principal Investigator)
Associate Professor
Director of Technology Enhanced Learning and Research
The Ohio State University
Phone: 614-292-6026
E-mail: acker.1@osu.edu


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