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Examination of asynchronous volumetric and frequency communication patterns in online courses and their impact on adult learner satisfaction

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Robert W. Treat

A Dissertation Submitted in

Partial Fulfillment of the

Requirements for the Degree of

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Barbara J Daley 11/28/06

Major Professor **Date**

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ABSTRACT

EXAMINATION OF ASYNCHRONOUS VOLUMETRIC AND FREQUENCY COMMUNICATION PATTERNS IN ONLINE COURSES AND THEIR IMPACT ON ADULT LEARNER SATISFACTION

by

Robert W. Treat

The University of Wisconsin - Milwaukee, 2006

Under the Supervision of Barbara J. Daley, Ph.D.

The purpose of this study was to investigate the relationship of online discussion board interactions of adult learners and their satisfaction with their experience. Specifically, this study's objectives were to examine the asynchronous volumetric and frequency textual communication patterns through online discussion boards and the association to adult learner satisfaction for 102 electronically surveyed adult learners at a mid-western university during the 2005-2006 academic year. Highly reliable (Cronbach alpha = 0.97) and valid data were collected from a learner satisfaction form developed specifically for the outcome variable of this study. Exploratory factor analysis provided

evidence that the data collected from the form were asymmetrically sub-structured into four distinct factors.

Communication constructs of momentum, force, and energy were created from physical parameters and determined to be the main predictor variables in this study. The communication constructs were significantly related to the outcome of learner satisfaction and collectively constituted the structural core of this study's model as determined by correlations and linear regression modeling. Moderator variables of learner prior experience and learner prior satisfaction were found to create a high-precision model of asynchronous volumetric and frequency communication patterns and learner satisfaction through correlations and interaction effects in regression analysis. The study provides core and high-precision models that link asynchronous textual communication for discussion boards in online courses to adult learner satisfaction.

Barbara A Daley 11/28/06

Major Professor **Date**

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Table of Contents

Appendices

List of Figures

List of Tables

That, which does not kill us, makes us stronger.

- Friedrich Nietzsche

CHAPTER I

Introduction

The purpose of this study was to investigate the relationship of online discussion board interactions of adult learners and their satisfaction with their experience. Specifically, this study's objectives were to examine the asynchronous volumetric and frequency textual communication patterns through online discussion boards and the association to adult learner satisfaction. Since time is a key parameter of this investigation as it is used to construct the main predictor variables in this study's adult learner satisfaction model, this chapter will be begin with a brief introduction to time and communication. This will be followed by sections on adult learners, online learning and asynchronous communication and finally the rate and energy of communication. Chapter II will provide a comprehensive literature review of these topics. Chapter III will describe the methodology of this study, while chapter IV presents the results and chapter V provides the discussion, implications for teaching and learning and future research.

Timing and Communication

In order to understand the nature of communication between people, researchers need to examine the nature of timing of that communication. The World Wide Web has changed the nature of communication between people, and so too has the timing of that communication been changed. Therefore, in order for this change in communication by the World Wide Web to be understood better, the relationship of timing and communication must be examined.

Adult learners of the first decade of the third millennium can easily recall a time (circa early 1990s) in world history without the World Wide Web. They can recall when

distance learning meant that learning at a distance correlated with a measurable span in time. The World Wide Web shattered the correlation between space and time for distance learners by making it possible to communicate from anywhere in the world at any time. Distance learning on the World Wide Web, often referred to specifically as online learning, makes available to the adult learner two general forms of communication: synchronous (real-time) and asynchronous (delayed-time). The temporal patterns of electronic synchronous communication parallel that of face-to-face (f2f) communication, and is not the focus of this study. The temporal dynamics of electronic asynchronous communication is unique, and is a major focal point for this study. In the context of this study, the impact of timing and communication through online discussion boards on adult learner satisfaction will be explored. Since the use of discussion boards necessitates a delay in communication, the temporal dynamics of asynchronous communication and its effects on adult learner satisfaction can be explored through this medium.

Overview of Time

People have many perceptions of what time means to them, but collectively adult learners become aware of two inevitable facts about it - there is precious little time in their lives, and it only decreases with age (Tien & Burnes, 2002). There is often an increased physical and psychological sensitivity to the passage of time (Sorli, 2004) during personal milestones in people's lives such as graduating from high school or college, getting married, having children, buying a first home, etc. For some, sensitivity can soon give way to apprehension, anxiety, fear, or even dread.

While some people accept the passage of time as simply the natural order of the universe, others wage a personal war with it as if it were something to be beaten, controlled, and mastered. It is not unusual to hear children and young adults say that they spend too much time in school, and that they can't wait until they can leave so they can become adults and have more control over their time. However, some adults who have stopped going to school for a while soon realize that some of the most satisfying times in their lives were spent in school learning. They return to school with a more practical perspective, which includes an awareness of limitations in time (Shmotkin & Eyal, 2003). Simons, Vansteenkiste, Lens, and Lacante (2004) has demonstrated that having a deep future time perspective is associated with enhanced motivation, more intensive persistence, deep conceptual learning, and better performance.

Adult learners are people who have come to the realization that learning is important to their own personal enrichment and satisfaction. They know that time is precious and that they must increase their skills in time management if they are to effectively pursue their studies at this later time in their lives. Time management allows adults to get more done in the time they have (Kozoll, 1982). However, in a society that is in a frustratingly perpetual state of motion, time is difficult to manage for many adult learners. Large numbers of adult learners have turned to online courses to help them manage their time better (Meyer, 2003). The semi-structured framework of online curriculum often necessitates that learners communicate with each other in a flexible, albeit somewhat regular span of time. This pseudo-periodic approach to time management provides adult learners a balance of flexibility and structure so that they can conveniently communicate with each other.

Communicating through text in an online environment can be done in real-time (synchronous) via instant messaging and chat rooms or delayed-time (asynchronous) via e-mail and discussion boards. The advantage of synchronous communication is that learners can get an immediate response from the teacher or other learners. The advantage of asynchronous communication is that it gives time for learners to reflect on what they want their audience to read from their writings (Browne, 2003). Consequently, this creates a delay that the audience must tolerate for a certain period of time. However, text that takes too long to appear for a given reader may as well not appear at all as it decreases in value according to the old adage, "too little, too late."

Since asynchronous communication has been used in online courses, some researchers are interested in how the amount of time that passes between individual electronic communications affects the satisfaction of learners (Wang, 2003). In asynchronous communication, the issue of time is important in at least two ways: (1) the consistency (regularity) of communication (Goode, 2002), and (2) the rate (speed) of communication (Wright, Marsh, & Miller, 2000). The aspect of consistency addresses the issues of flexibility (i.e., learning at the student's convenience) and interaction in online learning. Flexibility has been a focal point for marketing online education to potential students (Day & O'Donovan, 1988). However, flexibility (in terms of time) can conflict with the goal of maximizing interactions between learners (Tu & Corry, 2003). While it may be helpful for the learners to take advantage of flexibility, it may be detrimental to other learners who depend on interacting with them.

The second aspect of rate of communication addresses the issue of maximizing interactions between learners. The faster the rate of communication is between learners,

the more likely that the number of interactions will increase. Studying the consistency and rate of communication between learners will help describe the patterns of communication that develop between them.

Researchers and instructors need to understand how time impacts the lives of adult learners in online courses. It is important to analyze what patterns of communication are created, maintained, and dissolved between learners during the lifetime of a course. Interpersonal relationships are held together by communication and cannot be separated from it. Relationships develop over time through a negotiation process between those involved. The nature of the relationship is defined by the nature of communication between its members. Typically, people grow into a relationship gradually by getting to know more about one another through communication. Studying the patterns of communication helps to describe the patterns of interpersonal relationships (Kirkpatrick & Duck, 2004) amongst people.

Background

Concept of Time

The word "time" has many definitions. It is a concept that is hard to define in simpler terms which creates a circular logic and often is not precise enough to be useful. As a noun, and in the specific context of this study, it can be defined as a period of duration considered as a resource under a person's control and sufficient to accomplish something. More generally, it is the continuum of experience in which events pass from the future through the present to the past (Hyperdictionary, 2006). To ask the philosophical question "what is time?" is to ask whether the past-present-future distinction is objective and how

people should understand the flow of time. A good definition of time will be satisfactory only if it is backed up by a good theory.

Since ancient Greece, philosophers have considered the relationships of space, time, motion, and change. The Newtonian (classical) viewpoint which has predominated many Western cultures to the present, states that space and time are fundamental parameters, and motion and change are derived from them. The Einsteinian (modern) viewpoint of time and space, which is important in modern physics, states that time and space are part of a multidimensional space-time continuum and that motion and change are relative to the location in the continuum. According to relativistic theory (Einstein, 1920), all events appear to take place at a slower rate in a moving system when judged by a viewer in a stationary system, an experimentally confirmed effect known as time dilation (Hafele & Keating, 1972). For example, a moving clock will appear to run slower than a stationary clock of identical construction.

Additional viewpoints argue that people view time as situational, where the meaning of time is inherent to the relations between people and events. In modern Western societies, the predominant perspectives seem to be that there are two components of time: physical/chronological/public and psychological/private (Grondin, 2001). When referring to physical time people speak of the public time that a clock will measure much like the timestamp associated with electronic computer files. Somebody waiting for a response to e-mail or a discussion board posting are examples of psychological or private time.

Chronological time is a form of time that has been abstracted from its natural source (i.e., the Universe). It is arguable that this isn't really "time" at all, just another artificial

metric which humans have created to bring a sense of order to their lives (Hassan, 2003). However, this chronological time is so deeply embedded in society, that it is nearly impossible to ignore. Daily, weekly, monthly, yearly, and other spans of time structure the lives of people to the point that it has artificially imposed temporal rhythms in them and narrowed their horizons (Crow & Heath, 2002). The predominance of chronological time has dulled and repressed natural temporal rhythms.

Patterns of Time

It is normal to say that people perceive spatial relations between objects (e.g., two cars with a set distance between them). It also seems normal to talk of temporal relations (e.g., the screeching of an automobile braking hard before the sound of a crash). However, unlike the spatial dimensions of perception, time is not directly available to any sensory organ and can only be understood through change and the unfolding of events in people's lives (Coren & Ward, 1989). And yet, despite its transient nature, time is a dimension that has a significant impact upon a wide variety of psychological behaviors.

Many events in people's lives have a pattern that is structured through time (i.e., they have rhythms). Walking, talking, and music are examples of events that express patterns across a temporal domain. These patterns (and lack thereof) and their impact on social behavior can be observed and measured across a window of time (i.e., there is a functional relationship of these patterns with respect to time). Coordinating these patterns with other people's patterns requires a scheduling of said events, which also can be measured and observed (Jones & Boltz, 1989). The collection of data can be in the form of electronic data or paper surveys (Ballard & Seibold, 2004).

Adult Learners

Two primary reasons that are often cited for why adults do not participate in adult education programs are lack of time and money (Merriam & Caffarella, 1999). Most adult learners work full-time. Accordingly, the aim in teaching arrangements is to make full use of the development opportunities available in distance learning. Adult learners are self-directed (Tough 1967, 1971), problem-centered (Gounard, 1977), results oriented, and seek relevant information (Merriam, 2001) to use in their lives. The importance of learning relevant information to adult learners precipitates from their perceived limitations of time. Learning has to be applicable to their work or other responsibilities to be of value to them. Adults are practical, focusing on the aspects of a lesson most useful to them in their work.

These behavioral outcomes arise from what motivates adult learners (Rakich & Pittinger, 1999). Adult learners choose educational opportunities because it may provide any or all of the following: creation of new relationships, cognitive interest, personal advancement, social welfare, external expectations, etc. Therefore, it is suggested that in order to satisfy any or all of these outcomes, adult learners must budget their time in order to achieve them. One way that adult learners have tried to meet their temporal constraints is to involve them in online education.

Online Learning and Asynchronous Communication

Many technologies over the last four decades have finally merged to provide adults with the ability to participate in adult education programs in larger numbers. The technology of personal computers (born in the 1980s) connected over the physical structure of the Internet (1960s) permit communication via e-mail (1970s) and hypertext

(1990s). Coupled with today's learning management systems (2000s) such as Desire2Learn and BlackBoard, these technologies have created an online educational environment that allow adults to communicate with a speed and convenience never before seen with earlier versions of distance education.

Many online courses and programs will use these educational portals to facilitate better communication amongst the participants using software packages called discussion boards. Discussion boards are asynchronous communication interfaces, which allow learners to post textual messages and file attachments at their convenience so that other learners can review and respond to the material on their own time (Meyer, 2003).

Rate of Communication

In order to describe online communication patterns in discussion boards with physical parameters, it is necessary to operationalize kinetic and thermodynamic concepts used in the natural sciences such as momentum, force, and energy. Momentum and force are kinetic parameters, which are used to describe the motion of an object. The momentum of an object is simply the product of its mass and velocity (speed). Note: Velocity is defined as a change in position with respect to a change in time. Therefore, the more mass and/or velocity an object has, the greater its momentum. According to Isaac Newton's first law of mechanics, an object will always maintain constant momentum, unless an outside force acts on it (Newton, 1679). His second law of mechanics states that the force imparted to the object is directly proportional to its change in velocity (i.e., its acceleration). Force is a product of an object's mass and the acceleration it undergoes.

Momentum and force can be operationalized within the context of this research study, by making communication constructs from physical parameters as seen in Table 1-1. The

amount of text (e.g., word or character count) in a discussion board posting is analogous to the mass of an object, while the amount of time between postings can describe the rate (speed) of communication. Therefore, the momentum of a learner's online communication directly depends on how much text s/he writes (i.e., word count per posting) and how often he/she writes (i.e., elapsed time between postings) if the construction of the communication constructs parallels the construction of the physical parameters as seen in Table 1-1 and in chapter III. The content of the message may impact the learner's momentum, force, and energy, but this study will only investigate the quantitative nature of the messages, not the qualitative makeup (De Wever, Schellens, Valcke, & Van Keer, 2006). There are researchers who have recently assessed the qualitative components of discussion board forums through various modes of measurement (Marra, Moore, & Klimczak, 2004; Lockhorst, Admiraal, Pilot, & Veen, 2003).

Table 1-1

Kinetic Parameters and Communication Constructs

	Kinetic Parameters	**Communication Constructs**
Momentum	**= Mass x Velocity**	**= (Amount of text) x (Rate of posting text)**
Force	**= Mass x Acceleration**	**= (Amount of text) x (Change in rate of posting text)**

Therefore, if learners post a consistent amount of text at regular intervals of time, they have constant momentum. The more text that a learner posts and/or the more often the learner post their text on the discussion boards, the greater their momentum. If learners experience external forces, then changes in momentum will be observed due to a change in the rate of posting text. Greater external forces and/or a greater number of external

forces cause a greater change in learner momentum. Note that this change in momentum can either be an increase due to factors like increased pressure, interest or motivation, or a decrease due to external obligations, fatigue, or apathy. Sustaining the momentum of the discussion (Beaudin, 1999), forced interactions (Biesenbach-Lucas, 2003) and procrastination in responding to postings (Hew & Cheung, 2003) are kinetic problems associated with discussion boards.

Energy of Communication

Objects in the natural sciences are described thermodynamically, as well as kinetically, since objects may possess energy, like they have motion. Although text may be seen as a more abstract object than perhaps an automobile, it too has thermodynamic properties, which have been previously operationalized (Badalamenti & Langs, 1992).

There are two fundamental laws in science that apply to this study: (1) the conservation of momentum (Newton, 1679), and (2) the conservation of energy (von Mayer, 1842). The conservation of momentum states that a system will maintain constant momentum, unless external forces act on it. The conservation of energy states that energy can be neither created nor destroyed but may change form. Perhaps less well known is the fact that these two laws hold over time because of Noether's Theorem, which proves a relationship between symmetries in physics and conservation laws (Noether, 1918).

While energy can be described in many ways, mechanical energies are used to develop communication constructs in this study. There are two forms of mechanical energy: (1) kinetic energy (energy of motion), and (2) potential energy (energy of position). Mathematically, kinetic energy is related to momentum, but conceptually it's

quite different. For this study, the difference between momentum and kinetic energy will not be important, since the kinetics and thermodynamics of the discussion board communications will be analyzed separately.

The kinetic energy of an object depends on the mass and velocity of that object, functionally similar (but not identical) to momentum as seen in Table 1-2. There is a greater dependency on velocity for kinetic energy, as seen by the second-order relationship. However the potential energy of an object depends on the mass of an object, and its position in space with respect to a reference point (usually the surface of the planet). The potential energy of an object is often thought of as stored energy, waiting to be converted into other forms (e.g., kinetic energy). The operationalization of kinetic energy is similar to that of momentum as seen below in Table 1-2. However, the operationalization of potential energy is slightly more complex. The methodology chapter will describe the assumptions needed to estimate the parameter. Unlike kinetic energy, which can be calculated from actual data, potential energy must be either estimated directly or calculated as a difference of estimated total energy and actual total kinetic energy from the conservation of energy law. Regardless, higher activity on the discussion boards means greater kinetic energy and lower potential energy. Consequently, as one form of mechanical energy increases, the other decreases.

Table 1-2

Thermodynamic Parameters and Communication Constructs

Type of Energy	Thermodynamic Parameters	Communication Constructs
Kinetic Energy	= ½ (Mass) x (Velocity)^2	= ½ (Amount of text) x (Rate of posting text)^2
Potential Energy	= Mass x Height x Constant	= (Amount of text) x (Minimum distance) x (Constant)

Note: The constant for potential energy in terms of the thermodynamic parameters is the acceleration due to gravity (usually $g = 9.8\ m/s^2$), which under no other external forces, is the maximum acceleration a free-falling body will experience.

As it was with the kinetic parameters, the factor of time is useful in the development of thermodynamic constructs for this study, since it will give the rate of communication between learners and consequently determine their kinetic energy. While the kinetic energy is linked to the communication process directly through the amount of text and how often it's posted, the potential energy is linked to a potential source of untapped communication by how much text is posted, but not responded to from the other learners in the class.

Research on Learner Satisfaction

Due to an increasingly competitive educational environment and a declining availability of tax dollars, universities are becoming more aware of the importance of learner satisfaction. Moreover, studies have shown learner satisfaction to have a positive impact on learner motivation, learner retention (Pascarella & Terenzini, 1991), and recruiting efforts and fundraising (Elliott & Shin, 2002). Therefore, an analysis of factors influencing learner satisfaction may help learner retention. Thurmond, Wambach, and Connors (2002) and Wiers-Jenssen, Stensaker, and Grøgaard (2002) have stated recently that many past studies (Billings, Connors, & Skiba, 2001; Soon, Sook, Jung, & Im, 2000) on learner satisfaction have not factored in enough variables such as learner experience. Specifically, they felt that Alexander Astin's (1993) Input-Environment-Outcome (I-E-O) Model would help clarify whether it was the student inputs and/or the online environment

that was determining the outcome of learner satisfaction. Thurmond's (2003) dissertation examined many input and environmental variables as they impacted learner satisfaction in web-based courses. Two predominant variables that contributed to learner satisfaction were students' perceptions regarding their interaction with their instructors and students' perception of the technology. The overall regression findings supported the need to examine student characteristics and the educational environment when assessing learner satisfaction. Findings provided support for the idea that the interaction activities that occur in an online environment, but not necessarily student characteristics (i.e., Astin's input variables), and have a greater impact on students' satisfaction.

Oddly, all of these studies focus on how various predictor variables impact one single outcome: learner satisfaction. While this helps to account for the variability in the predictor variables, little is reported on the dimensions of the outcome variable. Recently, Elliott and Shin (2002) recognized the limitations associated with the traditional approach of measuring learner's overall satisfaction, which simply relies on a single-item measurement of their satisfaction. They proposed an approach, which utilized educational attributes, each learner's varying degree of satisfaction with each attribute, and the relative importance of each attribute. They developed a highly reliable learner satisfaction survey, which accounted for 20 components of learner satisfaction. This included, but was not limited to items such as valuable course content, knowledgeable and available faculty, tuition paid is a worthwhile investment, adequate computer labs, overall quality of instruction, etc.

Problem Statement

Online instruction has become an important component of higher education. An increasing number of colleges and universities are going on-line with courses and programs, while those already involved are expanding these activities to better serve existing student populations. This form of educational delivery raises new questions as to the essential nature and content of an educational experience and the resources required supporting it.

Evidence clearly shows that satisfied learners have a lower dropout rate than learners who feel less content (Pascarella & Terenzini, 1991). As an attempt to improve the retention of learners and quality of learning and teaching, universities and colleges assess learner satisfaction and the variables that impact it. The identification of a structured and stable relationship between these factors and satisfaction could give universities a 'benchmark' to compare with, when trying to identify and assess the strengths and weaknesses of their own learning environment (Wiers-Jenssen, Stensaker and Grøgaard, 2002).

Although online education is gaining momentum around the world, there are issues such as learner satisfaction that need to be explored in greater depth if teaching at a distance is to be effective. Studies of this type are important because many teachers who are being asked to design and teach online courses are wondering if students are satisfied with the online environments. An increasing number of academic institutions are recognizing the benefits of online courses that have CMC systems. Therefore, it is imperative that research be conducted into the facets of online communication that make learners satisfied with their experience. In this study, the patterns of communication will

be analyzed from constructs developed from physical parameters. The factor of time plays an integral role in the analysis of communication patterns through a kinetic and thermodynamic framework. Higher and more consistent rates of communication as seen through the kinetic framework should provide greater learner satisfaction. Additionally, untapped communication as seen through the thermodynamic framework will provide lower learner satisfaction.

While the kinetic and thermodynamic variables help to provide the fundamental structure of an asynchronous communication learner satisfaction model, it is recognized that there are many other mediator and moderator variables that have to be accounted for. Additional variables such as relative learner success, prior learner satisfaction, learner characteristics, peer characteristics, and instructor characteristics will have to be examined within this model, particularly since there is some contradictory evidence in the literature (Thurmond, 2003).

All online learning management systems have communication components built into their programs. Many universities and colleges throughout the country use systems such as Desire2Learn and BlackBoard, which provide electronic discussion boards which allow the learners to asynchronously communicate with each other. The technology that provides asynchronous communication relieves problems associated with synchronous communication as it allows learners to communicate at their own pace. However, there may be expectations placed on learners to communicate in regular intervals, so that the experience of online discussion is satisfactory for the class or group as a whole. It is expected that learners will contribute to the discussion board forums in fairly regular intervals, but outside forces may prevent that from happening. It is necessary to

investigate the association between the asynchronous communication patterns of online learners and their satisfaction with their experience so that all learners can benefit from a satisfactory experience with online education.

Research Study

The purpose of this study is to investigate the association between the asynchronous communication patterns of online learners and their satisfaction with their online experience. Communication patterns will be extracted directly from the visual interface of the online learning management system and entered into a database. The time between postings, the amount of words in each posting, and the lack of response to each posting will be used to determine the communication constructs (momentum, force, and energy) through a kinetic and thermodynamic framework. Learner satisfaction will be obtained from a learner satisfaction survey given to the learners at the end of the semester, available electronically through the educational portal. Mediator and moderator variables will also be examined through the learner satisfaction survey.

Research Hypothesis and Questions

The research hypothesis for this study is stated as follows: Changes in the consistency and abundance of postings in online discussion board threads will impact learner satisfaction in online courses. Therefore, the numbered research questions and lettered research sub-questions used to investigate this association are as follows:

1) How does the momentum of communication patterns in an online discussion board affect the outcome of learner satisfaction?

a) How does the learner satisfaction change from mid-semester to the end of the semester?

b) How do the individual learner satisfaction items group into larger learner satisfaction factors?

c) How does the amount of text posted and the rate of response change from mid-semester to the end of the semester?

d) How do the different forms of distance (degree, closeness, and betweenness) between learners change from mid-semester to the end of the semester?

e) How do the different forms of momentum (degree-based, closeness-based, and betweenness-based) change from mid-semester to the end of the semester?

2) How do external forces, which change the momentum of communication patterns in an online discussion board, affect the outcome of learner satisfaction? In other words, how does the collective change in amount of text posted, the rate of response and distance to other learners affect learner satisfaction?

3) How does the amount of kinetic and potential energy of communication patterns in an online discussion board affect the outcome of learner satisfaction? In other words, how does the presence/absence of learner response affect learner satisfaction?

a) How do the different forms of kinetic energy (degree-based, closeness-based, and betweenness-based) change from mid-semester to the end of the semester?

b) How do the different forms of potential energy (degree-based, closeness-based, and betweenness-based) change from mid-semester to the end of the semester?

4) How does learner prior experience moderate/mediate the relationships of momentum, force and/or energy with learner satisfaction?

5) How does learner prior satisfaction moderate/mediate the relationships of momentum, force and/or energy with learner satisfaction?

Operational Definitions

The following terms come from Hyperdictionary (2006) and Merriam-Webster's Collegiate Dictionary, (1993):

Adult Learner - person who learns from others and is a primarily self-directed, pragmatic, and autonomous individual and is 18 years or older.

Satisfaction - the fulfillment or gratification of a desire, need, or appetite.

Communication - The exchange of thoughts, messages, or information, as by speech, signals, writing, or behavior.

Pattern - a recognizably consistent series of related acts; (b) a composite of traits or features characteristic of an individual or a group.

Interactivity - two or more message exchanges between people in which the third and later messages are in response to the earlier messages.

Momentum - (a) impetus of a nonphysical process, such as an idea or a course of events; (b) impetus of a physical object in motion; (c) a measure of the motion of a body equal to the product of its mass and velocity.

Force - (a) a capacity for affecting behavior; (b) something that can compel through pressure or necessity; (c) the capacity to do work or cause physical change; (d) a vector quantity that tends to produce an acceleration of a body in the direction of its application.

Energy - (a) vitality and intensity of expression; (b) the capacity for work or vigorous activity; (c) a source of usable power.

Kinetic - (a) moving or causing motion; (b) active, as opposed to latent.

Kinetic Energy - the energy possessed by a body because of its motion, equal to one half the mass of the body times the square of its speed.

Potential - (a) existing in possibility, not in actuality; (b) being potent; (c) endowed with energy adequate to a result.

Potential Energy - the energy that exists in a body as a result of its position or condition rather than of its motion.

Moderator - a variable that affects the magnitude of effect that a predictor variable has on an outcome variable.

Mediator - a variable that acts as a "go-between" and mediates the relationship between a predictor variable and an outcome variable.

Significance

Distance education has had a long history in the world (Moore & Anderson, 2003). However, it has only been in the last decade that the electronic medium of the Internet was used with the hypertext transfer protocols developed by Tim Berners-Lee (1992) to facilitate rapid, asynchronous communication between learners. Consequently, the history of the research associated with online education covers a small period of time. Much needs to be learned about how learners interact with and in this relatively new

environment. Much of the early research focused on comparative studies between traditional (face-to-face) and online education (Warren & Holloman, 2005). This tended to focus on the deficiencies of either medium. Recently, the literature (Dennis, 2003; Smith, Ferguson, & Caris, 2001) has focused on the advantages of either environment and has recognized that each medium has its own strengths. Flexibility of learner involvement has often been used as a marketing tool for online courses, and it is important to examine the validity of such claims by researching the association between asynchronous communication and learner satisfaction.

Summary

Despite the fact that online courses and programs are continuing to increase in number, research on learner satisfaction in this medium is not keeping pace. It is necessary to examine how the communication patterns in the online medium affect learner satisfaction. This study will add to the body of research of the spatial and temporal dynamics of online communication and its association with adult learner satisfaction. A review of the literature is presented in chapter II. The methodologies used for the investigation follows in chapter III. Chapter IV will report the results generated from the data collected during the one-year study. Finally, chapter V will discuss the results from chapter IV, as well as implications for teaching and learning and future research.

CHAPTER II

Literature Review

Introduction

Learner satisfaction with online academic programs is often linked to success in many of those types of programs (Hong, Kwok-Wing, & Holton, 2003). Success in online courses and programs is predicated on a learner's success in communicating with other learners. Amongst other factors, successful communication requires consistent communication (Chaudier, 2004). Typically, disruptions in communication mean less successful communication, which naturally, should be avoided. The World Wide Web, which is a comprehensive communications network, has made communications opportunities clearly more abundant and efficient, but not unambiguously more consistent, successful, or satisfying. While new opportunities for people to communicate have increased since the development of the World Wide Web, the issue of whether these new modes of communication are satisfying or successful is still researchable. It is important to understand if these new modes of communication will be successful and satisfying for those learners who choose to use them, by investigating the patterns of those communications and linking this directly to learner satisfaction.

Written communication helps people to inform, persuade, or entertain each other using only a small set of textual characters. Written communication has advantages over oral communication in that it can leave a more objective and permanent record of people's thoughts and accomplishments. While perhaps an afterthought to objectivity and permanent record keeping, written communication offers the convenience of giving

people adequate time to organize their words in a logical and coherent manner. Most oral communication occurs with little preparation to do that.

Electronic communication has brought about interesting developments in the way learners use written communication. Since computers allow learners to type without the usual typographical barriers, they are able to transfer what they are thinking more quickly into what they are writing (Abdullah, 2003). On the other hand, learners are able to edit and retain their drafts until they want to commit to a written conversation with other learners.

During the later part of the twentieth century, the development of the Internet gave people in government and academia the opportunity to rapidly communicate with each other using text. This helped expedite written communication for some distance education courses that opted to use the Internet as a means of information transfer. Oddly enough, when Berners-Lee (1992) developed the graphical subset of the Internet known as the World Wide Web, the use of text-based communications such as electronic mail (e-mail) increased enormously. The graphical interfaces created for the World Wide Web had broad appeal to the masses and helped people to communicate that may never have had the opportunity to do so before. While graphics, audio, and video are components that enhance the experience of using the World Wide Web, written communication has flourished along side of these forms of information transfer.

While e-mail is unquestionably the most familiar way for the population as a whole to communicate through text, other forms of technology designed to facilitate written communication have developed since the 1990s. Discussion boards (forums), chat rooms, and instant messaging are three additional technologies of written communication

that have been developed to help people communicate with text more easily. While each of these four technologies has the advantage of liberating users from the spatial confinement of geography, only e-mail and discussion boards have the ability to release people from temporal constraints. E-mail and discussion boards both liberate the learners from the constraints of space and time, but it is more difficult for reasons of access and privacy to monitor and assess communication that occurs through e-mail.

Communication technologies serve to overcome the physical limitations of space and time. They shape human activities by changing, and hopefully improving the functional relationships between space and time in human interaction (Hägerstrand, 1970). The promise of communication technologies creating a global "networked" community is alluring and seductive, but also threatening. Those people who fail to adopt the use of these technologies run the risk of falling behind socially and economically (Zembylas & Vrasidas, 2005). However, despite the extensive adoption of communication technologies in colleges and universities, its impact on learning and teaching is considered minimal (Collis & van der Wende, 2002) and disappointing (Garrison & Anderson, 2000) by some researchers. There has been tremendous hype about the potential for communications technologies to change the very nature of adult learning and teaching (Bjarnason, 2003).

In order to examine the communication between learners, it is necessary to quantitatively analyze the spatial and temporal patterns that are created on the discussion boards. Treating the written text on a discussion board as an object of investigation affords the researcher the luxury of using physical laws to precisely study their movement. It is not uncommon to hear people describe everyday objects with terms such

as momentum, force, and energy (LaBrecque, 1998). As such, these three terms in particular will be used to describe the interactivity of communication patterns for the discussion boards. This of course, requires clear and concise definitions of these terms as they apply not only in the field of physics, but also in the context of studying learner communication patterns. Therefore, this study will use rigorously defined physical parameters (Wolfson & Pasachoff, 1995), which may be more easily recognized in the context of the natural sciences, but easily translates into factors useful in textual analysis (Tonfoni, 1996).

In order for this study to be academically sound, a literature review requires the following areas of research to be discussed as they apply specifically to this investigation: (1) adult learning, (2) online education, (3) interactivity, and (4) learner satisfaction. The use of physical concepts such as momentum, force, and energy and their development as communication constructs will be described in the section of interactivity and operationalized later in the chapter of methodology.

Adult Learners and Online Education

Some adult learners are self-directed (Tough, 1967, 1971; Knowles, 1970), problem-centered (Gounard, 1977), results oriented, and seek relevant information (Merriam, 2001) to use in their lives. The importance of learning relevant information to adult learners precipitates from their perceived limitations of time. Learning has to be applicable to their work or other responsibilities to be of value to them. Adults are practical, focusing on the aspects of a lesson most useful to them in their work. While they may be seen as independent and autonomous, they also value establishing meaningful relations and exchanging ideas (White & Weight, 2000). Naturally, the

ability to be self-directed, but communicate with others at their leisure is a natural position for adult learners in an online environment.

These behavioral outcomes arise from what motivates adult learners (Rakich & Pittinger, 1999). Adult learners choose educational opportunities because it may provide any or all of the following: creation of new relationships, cognitive interest, personal advancement, social welfare, external expectations, etc. Therefore, it is suggested that in order to satisfy any or all of these outcomes, adult learners must budget their time and overcome physical limitations in order to achieve them. One way that adult learners have tried to overcome temporal and spatial constraints is to become involved in online education.

The 2004 Sloan Survey of "Online Learning, Entering the Mainstream: The Quality and Extent of Online Education in the United States, 2003 and 2004," concludes that the expected average growth rate for online students for 2004 is 25 percent, up from 20 percent in 2003. All other factors being constant, this survey suggests a growing interest of learners in online education, and consequently a growing need to assess the outcomes of this type of learning.

The literature on online education has reported many advantages and disadvantages of the electronic medium. Of the reported advantages, online education supports greater freedom and flexibility in communication (McComb, 1993), which allows learners some relief to contribute at their own pace (Morgan, 2000). This permits learners' time to reflect on what they want to communicate and encourage critical thinking and self-directed learning (Aviv, Erlich, Ravid, & Geva, 2003).

Some of the reported disadvantages are the loss of visual and aural cues (Tiene, 2000; Burge, 1994), increased time spent on the course (Wiesenberg & Hutton, 1996), and low rates of interaction (Guzdial & Carroll, 2002).

Discussion Boards and Public Deliberation

Fundamentally, discussion boards offer a way to communicate and a means to meet other members of a community (Fichter, 2005). Learners communicate with one another in an online class by asking questions and getting information, but may also use them for purposes of inspiration, persuasion, and debate. Therefore, discussion board forums can be used as a medium for formal, public political discussion. The communication skills developed as a learner are pertinent to citizen engagement and public deliberation in the public sector. Since public deliberation is essential to democracy (Delli Carpini, Cook, & Jacobs, 2004), online deliberation is an easy way to engage the public in policy discussion. The literature suggests that the online discussion boards may help study deliberation and for increasing its use by citizens (Cappella, Price, & Nir, 2002).

Group interactions and the subsequent communication patterns generated from them can shape individual learner's opinions and behaviors (Price, Nir, & Cappella, 2006). The discussion boards can also marginalize participants if they do not feel free to post their opinions. If the boards are not moderated, group pressure may constrain learner's behaviors as well (Goldsborough & Page, 2005). Hurrell (2005) indicated that when discussion board participants developed and maintained norms of civil discourse, these norms helped to promote understanding and consensus-building.

The use of discussion boards extends beyond the academic sector and into the public domain. Since good deliberation requires active listening, vigorous debate and good

judgment, it would be logical to assume that online discussion boards can help facilitate the development of these skills.

Interactivity/Interactions and Online Education

The concept of interactivity in the online classroom is so important to the six accrediting bodies for universities and colleges in the United States (Accreditation, 2003) that when they released revised criteria for accreditation in 2001, it included the core concept of interactivity. Specifically, it stated that programs require, "intellectual interaction between student and faculty and encourage it between student and student." Research has indicated that increased interactivity in distance education is associated with higher achievement and learner satisfaction (Zirkin & Sumler, 1995).

While there is literature on defining interactivity in human communication according to Downes and McMillan (2000), a satisfactory theory has yet to be developed for it (Bucy, 2004; Sundar, 2004), most likely due to its complex nature (Roblyer & Wiencke, 2003). While many adult learning theories have been developed during the past two decades, none of them seems to adequately address the issue of interactivity (Bucy, 2004; Frey, 2003). This suggests that continued investigation into what interactivity means is necessary, so that an adequate theory can be developed for it.

The definition of interactivity to be used in the context of this study was one reported by Hacker (1996). Hacker, building on a definition from Rafaeli (1988), applies interactivity to the Internet environment, defining it as two or more message exchanges between people in which the third and later messages are in response to the earlier messages. Note that there is also the related, but more focused term of interaction which is slightly different in meaning, but is often used interchangeably with interactivity. An

interaction suggests an interchange that occupies a small, finite window of time. Interactivity implies an ongoing process occupying a relatively large, potentially endless amount of time. The two terms convey the same fundamental information but across different periods of time, and may be used interchangeably within the context of this review.

In online education, there are four basic forms of interaction: learner-teacher, learner-content, learner-learner (Moore, 1989), and more recently learner-technology (Hanna, Glowacki-Dudka, & Conceição-Runlee, 2000; Palloff & Pratt, 2001). Modern constructivist theorists (e.g., situated social constructivists) stress the value of learner-learner interaction in investigating and developing multiple perspectives. Peer interaction is critical to the development of communities of learning (Wenger, McDermott, & Snyder, 2002) that allow learners to develop interpersonal skills, and to investigate tacit knowledge shared by community members.

The use of discussion boards in online courses, which fosters deeper discussions (Herod, 2003) and necessitates a high level of interpersonal interactivity of learners with each other and/or the instructor, should require higher-level competencies and learner skills such as analysis, synthesis, and evaluation (Meyer, 2004; Bloom, 1956). The interactivity rests on bi-directional communication such that participants will have to exchange positions (i.e., sender/receiver) from time to time otherwise there is no negotiation of meaning.

Reports have indicated that increased interaction in distance education is associated with learner satisfaction. Picciano (2002) reported a moderately strong correlation ($r = 0.673$; $p < 0.05$) between learner's perceptions of their interaction in an online course and

their perceptions of the quality of their learning. However, he also reported a moderate correlation ($r = 0.576$; $p < 0.05$) between perceived number of postings per learner and actual number of postings per learner. Considered collectively, these two correlations suggest a modest relationship between actual number of postings and learner perception of the quality of their learning.

Jung, Choi, Lim, and Leem (2002) concluded that of the three types of asynchronous interactivity (independent variable) of online courses in their study (academic, collaborative, and social), collaboration among the learners was best related to learner satisfaction (dependent variable). However, they did report that they weren't sure if other confounding variables could be contributing to some of the reported results of learner satisfaction. Although the report is somewhat dated, contradictory evidence from Zhang and Fulford (1994) illustrated that students' perceptions of interaction in a distance-learning course did not correlate with actual interaction (either as the number of messages or time spent interacting).

In addition to the reported problem of low rates of interaction in online courses that were mentioned previously (Guzdial & Carroll, 2002), other problems are specifically linked to asynchronous discussion boards. Sustaining the momentum of the discussion (Beaudin, 1999), forced interactions (Biesenbach-Lucas, 2003), procrastination in responding to postings (Hew & Cheung, 2003), and a lack of time (Atack & Rankin, 2002) are kinetic aspects of discussion board postings.

In order to understand the reasons for kinetic problems with online education, it is important to develop a model that will use kinetic parameters. Since kinetics is the physics of motion, parameters from this sub-field of physics will be used to develop

constructs in asynchronous communication to describe the patterns in discussion board postings. The use of kinetic and thermodynamic parameters from the natural sciences to describe text has already been reported (Tonfoni, 1996). In this study, the derived kinetic parameters of momentum and force (which are constructed from the fundamental parameters of time, mass, and distance) and the thermodynamic parameter of energy (constructed from the same fundamental parameters) will be used to develop the model. It is necessary to describe these fundamental parameters, how they are used to construct derived parameters of momentum, force, and energy, and how they ultimately will be used to create the communication constructs used in this study. While the measurement of fundamental parameters and calculation of derived parameters will be explained in the methodology section, it is helpful to illustrate how the derived parameter of momentum (p) is calculated from the fundamental parameters of time (t), mass (m), and distance (d). While there is a directly proportional relationship between momentum and mass as well as momentum and distance, there is an inversely proportional relationship between momentum and time (Newton, 1679):

Equation 1: momentum = [(mass) x (distance)] / [time]

This equation reduces itself down symbolically to:

Equation 2: $p = m \cdot d / t$

Since the physical parameter of time will not conceptually change from its original meaning in the natural sciences to its meaning in this study, it will be easiest to discuss it first. However, physical time is not the only component of time to consider. The concept of time is often described in two ways: physical and psychological time. The difference

between these two versions of time is a source of conflict for learners in that they are often incoherent with respect to one another.

Fundamental Parameter of Time

In modern Western societies, the predominant perspectives seem to be that there are two components of time: physical/chronological/public and psychological/private (Poppel, 1978). When referring to physical time people speak of the public time that a clock will measure much like the timestamp associated with textual postings on a discussion board or electronic files on a computer. On the other hand, psychological time is private time. Somebody waiting for a response to a discussion board posting or e-mail is an example of psychological time.

In this study, it is the artificial metric of physical time that is measured in order to determine key parameters of this study: momentum, force, and energy (to be described later). Of the two components of time, physical time is the easier one to measure. However, the perception of how time passes (e.g., waiting for a response to a discussion board posting), is a factor that also needs to be considered in understanding of this concept. Psychological time is best understood as consciousness of physical time, yet the relationship between the two is still somewhat of a mystery (Chersky, 2003). The environment can affect one's conception of time where a rich spatial environment can have the effect of making an experience seem longer than it actually is. When we are younger time seems to pass more slowly. It all has to do with how we process information from our environment.

What is also important to recognize is that what is being measured in this study is the difference in two points of time that has meaning. In other words, it is the duration of

elapsed time between two or more discussion board postings that is significant, not necessarily when the postings occurred, since we experience time more as an interval than an as instant (Lucas, 1973). The doctrine of the specious present is a doctrine about the direct perception of the temporal relation between events. People don't scan reality instant by instant. Instead, each act of apprehension presents a finite period of time in which several non-simultaneous events take place (Hoerl, 1998).

Physical time is easily measured through electronic timestamps of discussion board postings, and will be used to calculate learner momentum, external forces, and energy. If learners post to the discussion boards in regular intervals of physical time, they will have a constant momentum (assuming constant values of mass and distance, which are described in subsequent sections). However, external forces (e.g., work, personal responsibilities, etc.) may disrupt that momentum and create irregular intervals of time between discussion board postings. In physics, the momentum of a system will change when impacted by external forces under a law called the conservation of momentum. The conservation of momentum law states that the total momentum of a system will be constant, unless acted on by external forces. Beaudin (1999) and Winiecki (1999) have both reported that sustaining the momentum of discussion board postings as a problem in online courses. In addition, Barley (1988) has reported that temporal asymmetries can be a source of conflict among groups. Furthermore, Sawyer and Southwick (2002) and Barley (1988) both recounted that in their studies of organizations, temporal asymmetries reflected differing perceptions of time and as they became more pronounced debilitating effects were seen in terms of the progress of organizational projects.

Monitoring the passage of physical time between discussion board postings must be accompanied by additional information (i.e., mass and distance) in order to describe the momentum. The fundamental parameters of mass and distance are described in the next two sections.

Fundamental Parameter of Mass

In order to describe the momentum, force, and energy of discussion board postings, it will be necessary to create communication constructs from the fundamental physical parameters of mass and distance as well as time. Conceptually, the parameter of mass is the less difficult of the two to translate into a construct of communication. In physics, mass is the quantity of matter in an object (Wolfson & Pasachoff, 1995). In this study, the mass will be considered the quantity of text (i.e., the number of words) per posting.

Combining the two fundamental parameters of mass and time as they are in equations 1 and 2 illustrates that momentum is directly proportional to mass, but inversely proportional to time. In other words, the momentum of a learner's message will have more momentum if there is more text in the message and/or there is a smaller lapse of time between that message and the one it responded to. However, there is the concern that there is a point of limiting returns, in that paradoxically more equals less. Some authors (Shedletsky & Aitken, 2001) have stated that too much text equals too much work, while Ainsworth (2000) questions if interaction is even worth the effort, which may adversely impact learner satisfaction. In other words, there may be a linear relationship between momentum and learner satisfaction over a given domain of values, but may be inverted after a given amount of momentum, due to saturating amounts of text (mass).

Fundamental Parameter of Distance

The fundamental parameter of distance is the last of three fundamental parameters that are used to construct the derived parameters of momentum, force, and energy. While the parameters of time and mass are easy to conceptualize in physics and in the context of the discussion board text, the concept of distance will require more explanation as it is transferred from physics to communication. In order to do this, parameters from social network analysis will be used to generate a construct of distance. After that, the three fundamental parameters will be used to construct the kinetic parameters of momentum and force, as well as the thermodynamic parameter of energy. The next section is a brief overview of social network analysis, which will be used to develop the construct of distance for this study.

Social Network Analysis

A social network is a set of people or groups (called actors) and the relations (called ties or links) that hold them together. The actors exchange resources (text, data, information, goods, services, support, etc.), which then connect them in a social network. The position of an actor within a social network is called a node, which is held together by ties. A tie connects a pair of actors by one or more relations. Pairs may maintain a tie based on one relation only, e.g., posting a message to a discussion board, or based on many relations, such as using e-mail, chat rooms, and instant messaging.

Social network analysis (SNA) is the study of how the social structure of relationships around a person, group, or organization affects beliefs or behaviors (Wasserman & Faust, 1994). SNA has its origins in the field of sociometry (Moreno, 1937) as an attempt to quantify social relationships. Granovetter (1973) expanded the use of social networks to

help explain many different real-life phenomena in the social sciences. SNA has been a useful tool in anthropology (Freeman, 1978), sociology (Faust & Skvoretz, 2002), and psychology (Freeman & Webster, 1994). It has important applications in the study of human communications (Freeman, 1984), international relations (Faust, Willert, Rowlee, & Skvoretz, 2002), organizational behavior (White, Owen-Smith, Moody, & Powell, 2004), cooperation and conflict (Miller, Butts, & Rode, 2002), and health research (Michael, Colditz, Coakley, & Kawachi, 1999).

SNA is focused on uncovering the patterning of people's interaction. As a specific example, SNA can focus on the communication structure of an organization. Structural features that can be revealed through the use of SNA are the communication (formal and informal) patterns in an organization or the identification of groups (cliques or functional groups) within the organization.

The unit of analysis in SNA is not the individual (actor), but the relationship (tie/link) between them. Consequently, actors and their actions are viewed as interdependent rather than independent. The relational ties between actors are channels for transfer of resources. Content, direction, and strength characterize the relations. The content of a relation refers to the resource (in this case the discussion board text) that is exchanged. A relation can be directed or undirected and can differ in magnitude of strength. With respect to communication, actors may communicate daily, weekly, or yearly. What they exchange in that communication may be in small or large amounts and may be important or trivial. These aspects of relationships measure different types of relational strength.

SNA will be used to determine the fundamental parameter of distance, which will then be used to calculate the derived parameters of momentum, force, and energy. In physics,

the parameter of distance is the path length an object travels. To understand its meaning within the derived parameter of momentum, consider the following explanation. Two objects with the same mass that have traveled different distances in the same amount of time have different momentum. The object that travels a farther distance has a greater momentum.

In SNA, statistical values such as degree can be used to determine distance. Generally, actors that are more central to the network structure, have a higher value of degree (or more connections), tend to have favored positions, and hence more momentum. Therefore, those learners who have more connections on the discussion boards are posting and/or receiving more textual responses than other learners are.

Many of the basic parameters in SNA primarily deal with direct connections between actors. However, the complexity of people communicating in networks can be more complex than this. One main approach to analyzing the complexity of actor relationships is to examine the distance between them, which is a measure of how many steps a message must travel from sender to receiver. There are different ways to ascertain the distance between actors. While the geodesic distance is useful for describing the minimum distance between actors, it only examines a single connection between actors. One can also measure the vulnerability of the connection between actors (flow), the pairwise solidarity of actors (Hubbell, 1965), and the potential influence of actors on others (Taylor, 1970).

Haythornthwaite (2001) explored computer-mediated communication (CMC) with SNA. Her case study focused on many aspects of interactions in a computer-supported distance learning class, which she referred to as multiplexity. What Haythornthwaite

reported was that the network density (number of pairs connected relative to the maximum number of connections) decreased for the type of media as follows: discussion boards (1.00), Internet Relay Chat (0.87), e-mail (0.51), and NetMeeting (0.05). In addition, the densities decreased for the types of interaction as follows: collaborative work (1.00), exchanging advice (0.97), socializing (0.84) and offering emotional support (0.78). Correlations between collaborative work and exchanging advice improved considerably over the three five-week periods of analysis from $r = 0.55$ to $r = 0.69$ to $r = 0.92$, which suggest that these two types of interactions for these relations are converging. The result also suggest that at least within the context of her small sample ($N = 14$), that the discussion board was the type of media that had the most overall interaction, and that collaborating on schoolwork and exchanging advice about it created more dense networks than socializing and emotional support.

There was some data on the centrality positions (ranks) of the fourteen learners with respect to the type of media and type of interaction. This was done since the fourteen learners were entered into four small groups of four of five members and seemed to illustrate that team membership influenced centrality (i.e., members with similar levels of centrality were in the same group) and that this was consistent for the type of media and interaction.

One concern with the data was that it was collected as self-reports of frequency of communication by contacting the learners by phone three times over the fifteen-week class period. This of course can lead to some differences to studies like this one which will solely focus on discussion board interactions which are electronically verified and do not depend on learner memories.

Concepts of Motion

Momentum and force are physical concepts of motion. The algebraic description of these terms is reserved for the methodology section. However, a brief history of these two kinetic parameters is necessary to understand how they eventually came to be important in the three physical laws of Newtonian mechanics, and how that directly relates to their use as communication constructs in this study.

While written records have indicated that philosophers have considered the relationships of space, time, motion, and change since the time of ancient Greece (circa 3500 BC), it wasn't until two thousand years later that records indicate a formal investigation into the concept of time. Aristotelian tradition held that universal laws could be worked out mentally, and that empirical evidence collected through investigation wasn't necessary. However, in the seventeenth century, empirical investigation into the motion of moving objects set the groundwork for scientific evidence to support or refute ancient concepts of time.

While Galileo Galilei (1632) is best known for his work on heliocentric theory (according to which the sun is at the center of the solar system), his work on the acceleration of moving objects was helpful to Isaac Newton (1679) as his basis for his three laws of motion. These laws are fundamentally important in the natural sciences, particularly in the field of mechanics (physics of motion) and will be useful for developing communication constructs in this study. These three laws are summarized below. It is helpful to consider in the conceptual framework of this study that the object mentioned in the first two laws is quantified by the parameter of mass, which in the case of this study is the learner's text posted on the discussion boards.

Law 1: An object will always maintain constant momentum, unless an outside force acts on it.

Law 2: The force imparted to the object is directly proportional to its change in velocity (i.e., its acceleration). Force is a product of an object's mass and the acceleration it undergoes.

Law 3: For every action, there is an equal and opposite reaction.

The parameters of velocity, acceleration, momentum, and force used in Newton's three laws of mechanics are derived from the three fundamental parameters of time, mass, and distance (see chapter III). Consequently, investigations into the motion of objects, requires measurements of time, mass, and distance. The Newtonian (classical) viewpoint (Newton, 1679), which has predominated many Western cultures to the present states that space and time are fundamental parameters, and motion and change are derived from them. The Einsteinian viewpoint (Einstein, 1920), which is important in modern physics states that time and space are part of a multidimensional space-time continuum and that motion and change are relative to the location in the continuum. The classical viewpoint holds under ordinary circumstances, and will be used for this study.

Momentum, Force, and Asynchronous Communication

Much of the known world is metered by physical time. The schedules of adult learners are often calibrated to the nearest minute as they race to class during the week. The online environment has promised learners the ability to learn anywhere at anytime thus relieving them of some spatial and temporal constraints, normally imposed by class locations and schedules. However, while online courses have few spatial limits in the

world (e.g., physical access to a computer is one such limit); it does have some temporal boundaries. While participation in an online course is usually not controlled down to the hour or minute (e.g., synchronous communications in chat room or instant messaging are exceptions), it is usually controlled on a daily or weekly basis. Learners are expected to participate on a regular basis (i.e., maintain constant momentum) according to course guidelines and rules, which eventually become the expectations of their peers. However, these rules may be broken (i.e., momentum is no longer constant) due to external forces, which leads to a breakdown in participation and interaction amongst the learners. If learners do not participate on a regular basis, they are not maintaining a constant momentum, due to some external forces on their lives (e.g., obligations to family, friends or work, disinterest, apathy, etc.).

It is hypothesized that greater learner momentum and positive changes in momentum due to external forces will result in greater learner satisfaction.

Concepts of Energy

The kinetic model mentioned above is useful for examining the posting of text on a discussion board, so that a relationship between the rate of learner communication and learner satisfaction is established in asynchronous communication. However, the lack of participation by some learners may also affect to the level of learner satisfaction. In order to examine the lack of learner participation, a thermodynamic model will be created, where participation will be reflected through components of energy. Tonfoni (1996) has stated that the thermodynamics of text is concerned with information distribution and structure, which can now be applied to discussion boards in online courses. Tonfoni even goes so far as to move beyond classical physics into quantum physics, and suggests that

communicative energy can be described through the recently established Quantum Theory of Language (Lewis, 2003; Bohnenkamp, 1989; Booker, 1990). A few researchers since Tonfoni have analyzed the thermodynamics of text, but the object of study in each case was a novel (Houen, 1998; Whitworth, 1998), and the thermodynamic parameter was entropy.

Energy can be classified in many ways, but two forms of mechanical energy are useful for this study. Kinetic energy is energy of motion, while potential energy is energy that's stored (Wolfson & Pasachoff, 1995). As with the concept of momentum, there is a conservation law called the conservation of energy. In this case, the total energy of a system is constant, and energy is neither created nor destroyed. Therefore, the total energy of this system will equal the sum of kinetic and potential energy. The kinetic energy is algebraically related to momentum, but conceptually it is different. In this study, the amount of kinetic energy will reflect how much text is being posted on the discussion boards and at what rate it is for each learner. The potential energy will reflect how much text is not being responded to on the discussion boards. Methodologically, it is easy to calculate kinetic energy directly from actual data. The potential energy will be slightly more difficult as it will have to be estimated.

It is hypothesized that greater learner kinetic energy (and therefore lower learner potential energy) will result in greater learner satisfaction.

Learner Satisfaction

In an era of an increasingly competitive and dynamic educational environment, universities are becoming aware that learner satisfaction is important to address and assess, if they expect to remain competitive in the academic marketplace. Many

measurements of learner satisfaction treat it as a unidimensional construct, which ignores the complexity of the phenomenon. Recently, Elliott and Shin (2002) developed a weighted gap score analysis approach using multiple items to improve the diagnostic value of the learner satisfaction measurement. The form that they used, called the Student Satisfaction Inventory (SSI), had a high internal reliability (Cronbach alpha = 0.97) and had demonstrated a high convergent validity ($r = 0.71$; $p < 0.00001$) with the College Student Satisfaction Survey (CSSQ). Correlation analysis between overall and aggregate learner satisfaction scores (averaged from 20 individual items), where $N = 1805$, yielded a moderate correlation of $r = 0.487$ ($p < 0.0001$). This was most likely due to negative correlations between single individual learner satisfaction items with the overall learner satisfaction. Stepwise regression analysis revealed that some of the individual learner satisfaction items could not significantly account for the variability in the overall learner satisfaction. Consequently, their analysis was able to reveal which items could be removed as redundant items. However, while this might improve the correlation between overall and aggregate learner satisfaction scores, it might reduce the internal reliability. The authors did not report on potential changes to internal reliability due to the removal of any of the 20 individual learner satisfaction items. While the study from Elliott and Shin focused on learner satisfaction from a general perspective, the approach will be applied to this study in the narrow context of asynchronous communication as it supports a format and structure to be used in this study's learner satisfaction survey.

The literature suggests that only in the last few years that focus on how communication will affect learner satisfaction has become important. Downs and Hazen

(1977) and Hecht (1978) were some of the first researchers to describe communication satisfaction as a socio-emotional outcome resulting from communication interactions. Recently, Gray and Laidlaw (2004) examined ways of improving the measurement of communication satisfaction, which was done with the 40-item Communication Satisfaction Questionnaire (CSQ) that was developed by Downs and Hazen (1977). As with the earlier report by Downs and Hazen (1977), they studied the models that described satisfaction within the context of organizational communication, but made some minor revisions to improve the reliability and validity of the instrument and clarifying the factor structure.

Essentially, Gray and Laidlaw trimmed some items from the original CSQ to clarify factor structure, but this reduced the internal reliability from 0.94 (Downs & Hazen, 1977) to 0.80. Naturally, data are contextual, and it's possible that the smaller sample size used by Gray and Laidlaw (N = 127) compared to Downs and Hazen (N = 181) decreased the internal reliability. While initial comparisons between these two forms make at first glance seem trivial, it reveals that instrument modification can inadvertently reduce the quality of some statistical measurements while improving others. Data that produces a reliability of 0.80 is considered good in academic research, but may not be adequate for high-stakes assessment or commercial purposes. Gray and Laidlaw researched the improvement in the quality of this instrument from an academic standpoint, while Downs and Hazen originally produced their CSQ form for commercial purposes.

Mean inter-item correlations between individual learner satisfaction items ranged from 0.49 to 0.70 for Gray and Laidlaw's study, which provided evidence of convergent

validity of those items. This suggests that the items are covering a broad range of characteristics of communication satisfaction. However, correlations between the factors ranged from 0.46 to 0.81, which might suggest that there is a single communication construct which underlies all of the factors, but also hints at some factor redundancy. The studies are useful within the context of asynchronous communication, since many of the factors (e.g., horizontal communication, supervisory communication, personal feedback, etc.) in the models are related to this study.

Most importantly, the researchers provided evidence through factor analysis that communication satisfaction is a multidimensional construct, further supported by reports from Crino and White (1981) as well as Downs (1988). This does contrast with a study by Verona (1996), where the factors were so closely related they were essentially measuring the same construct. However, the majority of reports seem to support a multidimensional construct for communication satisfaction.

In the context of education, House (1999) used Astin's (1993) I-E-O model and concluded that the characteristics of the classroom environment (e.g., academic experiences) exerted a causal influence on learner satisfaction. Other researchers have used Astin's I-E-O model in education, but used outcomes that this study does not focus on such as obtaining a degree (Knight, 1994), learner persistence and performance (Campbell & Blakely, 1996), and learner success (Long, 1993).

In the context of online education, Thurmond, Wambach, Connors, and Frey (2002) have indicated that it is the characteristics of the online environment and not student attributes that affect learner satisfaction. By controlling for student attributes (perception of computer skills, knowledge of communications technology, number of Web courses

taken, age, and distance from main campus), their experimental study suggests that what happens in the course, not what students bring to it, contributes to their satisfaction. This may be an over-simplification of their results since Thurmond (2003) later remarked that the literature was somewhat contradictory on the effects of student attributes on learner satisfaction. This suggests a need to further examine mediator and moderator variables that impact learner satisfaction in an online environment.

Wang (2003) doesn't cite Thurmond et al. (2002) in his study (nor does Thurmond cite Wang), and therefore his results independently support what Thurmond's group reports: learner satisfaction is based on the characteristics of the online environment. Wang's assessment of learner satisfaction with asynchronous electronic learning systems (ELS) examined evidence of reliability, criterion-related validity, convergent validity, and discriminant validity with their data. As did Elliott and Shin (2002) and Gray and Laidlaw (2004), Wang sought to refine his instrument through factor analysis. The original 24-item instrument was scaled down to four factors consisting of 17 items with a high internal reliability (Cronbach alpha = 0.93). The inter-item correlation matrix revealed that items within a factor were no lower than r = 0.50, suggesting good convergent validity. Discriminant validity for each item was tested by counting the number of times that the individual item correlates higher with items of other factors than with items of its own theoretical factor. Only 14 violations from 216 comparisons occurred, which meets the criterion set forth by Campbell and Fiske (1959) that this should occur less than 50 percent of the time.

However, Debourgh (1998) reported that learner satisfaction depended more on the quality and effectiveness of the instructor and the instruction than on the technology. In

the context of this study, it would be possible to control for student attributes, but not instructor attributes due to the limitations in resources (e.g., access to data from multiple classes and time).

Earlier studies (Arbaugh, 2000; Ryan, Carlton, & Ali, 1998; Soon, Sook, Jung, & Im, 2000) did not control for students characteristics (e.g., academic and cognitive skills) in their analysis. Thurmond et al. (2002) had reported that one of the strongest predictor variables of learner satisfaction was receiving timely feedback from the instructor ($r = 0.514$; $p < 0.01$), which supports the investigation in this study insofar as timely feedback is a temporal communication factor. While there were some variables in their study that correlated higher with learner satisfaction, receiving timely feedback was the most applicable to this study, and the correlation was moderate at best, since it can only account for 26.4 percent of the variability in the dependent variable.

Thurmond's group (2003) also indicated that there was a moderate, positive relationship between the outcome of learner satisfaction and the predictor variables of actively participating in scheduled discussions ($r = 0.504$; $p < 0.01$) and of likelihood of group/team participation ($r = 0.418$; $p < 0.01$). This seems to support the notion of a positive relation between interaction and learner satisfaction. In addition, Vamosi, Pierce, and Slotkin (2004) have stated that interaction and time management contributed to the significant difference in the comparison of online-learning and face-to-face learning delivery modes of instruction. According to the authors, the online learning component hindered mastery of course material, diminished learner effectiveness in learning the material, and made the course less interesting to the learners, all of which negatively affected learner satisfaction.

Roblyer and Wiencke (2003) described how findings from theory and research were used to develop a rubric for assessing interactive qualities in distance courses, and examine the role of interaction in enhancing achievement and learner satisfaction in distance learning courses. They reported that instructor engagement and social-rapport-building designs for interaction correlated positively with learner satisfaction.

Finally, Thompson and Coovert (2003) examined some of the shortcomings of CMC and the impact on learner performance and satisfaction. Long, confusing discussions and temporal pressure could adversely affect the performance and satisfaction of learners in an online environment. The data reported that there was a statistically significant, yet negative correlation ($r = -0.36$; $p < 0.03$) between discussion time and learner satisfaction. This would seem to suggest that there is a point of limiting returns of time spent on discussion in CMC as it relates to learner satisfaction.

In conclusion, the studies by Gray and Laidlaw (2004); Wang (2003); Elliott, and Shin (2002); and Downs and Hazen (1977) suggest the same aspects of learner satisfaction as an outcome: it is a multi-item construct which can be grouped into factors to produce a form with strong internal reliability. However, in each study, the forms were pilot-tested and factor analysis required a modification of the original forms, resulting in a loss of some preliminary learner satisfaction items. Wang (2003) and Thurmond et al. (2002) independently reported that learner satisfaction is based on the characteristics of the online environment, not on learner attributes.

It would be wise to examine the association of asynchronous communication and learner satisfaction in online courses taking into account mediator and moderator variables, particularly if there is still some debate in the literature about their effects on

satisfaction. Chapter three will illustrate the asynchronous communication learner satisfaction model to be examined, which includes the main predictor variables of momentum, force, and energy, and additional mediator and moderator variables.

Summary

Learner satisfaction with online academic programs is predicated on a learner's success in communicating abundantly and consistently with the instructor and other learners. The World Wide Web has made communications opportunities clearly more abundant and efficient, but not unambiguously more consistent, successful, or satisfying. It is important to understand if these new modes of communication will be successful and satisfying for learners in online courses, by investigating the patterns of those communications and linking this directly to learner satisfaction.

Previous literature has indicated that interactivity in the online classroom is important and needs further investigation. Creating communication constructs from the physical parameters of momentum, force, and energy will create a mathematical model to help explain the impact of abundant and consistent asynchronous communication on learner satisfaction in online courses. Accounting for additional mediator and moderator variables will create a more precise, but perhaps a less parsimonious model.

CHAPTER III

Methodology

Chapter II examined the literature of communication patterns of adult learners in online courses. Review of the literature reveals gaps in understanding the asynchronous communication patterns of discussion boards used in online courses and their effect on learner satisfaction over time. The asynchronous communication patterns are described and analyzed through three key physical parameters: momentum, force, and energy. The calculation of these parameters is explained later in this chapter, but their conceptual meaning will be described below.

In physics, an object's momentum depends on three things: (1) how much material it has (mass), (2) how far it travels (distance), and (3) how long it takes to move to where it travels to (time). If external forces are present, then the constant momentum of the object will change in direct proportion to the forces. These two parameters describe the kinetic components of an object that moves. Furthermore, all objects have energy. Energy of motion (kinetic energy) and energy of position (potential energy) are parameters used to describe the thermodynamic components of the object. The mathematical relationship of these parameters to one another can be seen through their calculations, which is presented later in the chapter. However, the relationship of these physical parameters to the communication constructs used in this study is explained as follows.

Communication is a physical process and is easily measured when it occurs on discussion boards in online courses. The amount of communication is measured through three things: (1) the amount of text that learners produce (mass), (2) how long it takes to produce the text (time), and (3) how far the message travels through the network of

learners (distance). Collectively, these three variables are used to calculate the momentum of the communication. Disruptions in the momentum are easily quantified and are directly related to the external forces (e.g., the learner has obligations other than communicating on the discussion boards). Since communication has momentum, it will possess kinetic energy. However, not everyone responds to a given learners communication on a discussion board. This absence in communication can be characterized as a potential to communicate. Therefore, the presence and absence of communication will be characterized as kinetic energy and potential energy, respectively.

The three communication predictor variables of momentum, force, and energy were measured alongside the outcome variable of learner satisfaction, and their relationships to each other were analyzed. These relationships constructed the core model of this study. Furthermore, learner prior experience and learner prior satisfaction were examined as potential mediator and/or moderator variables and used to create a high-precision model. This chapter will describe the methods used to examine all of these relationships using the following numbered research questions and lettered research sub-questions:

Research Questions

1) How does the momentum of communication patterns in an online discussion board affect the outcome of learner satisfaction?

a) How does the learner satisfaction change from mid-semester to the end of the semester?

b) How do the individual learner satisfaction items group into larger learner satisfaction factors?

c) How does the amount of text posted and the rate of response change from mid-semester to the end of the semester?

d) How do the different forms of distance (degree, closeness, and betweenness) between learners change from mid-semester to the end of the semester?

e) How do the different forms of momentum (degree-based, closeness-based, and betweenness-based) change from mid-semester to the end of the semester?

2) How do external forces, which change the momentum of communication patterns in an online discussion board, affect the outcome of learner satisfaction? In other words, how does the collective change in amount of text posted, the rate of response and distance to other learners affect learner satisfaction?

3) How does the amount of kinetic and potential energy of communication patterns in an online discussion board affect the outcome of learner satisfaction? In other words, how does the presence/absence of learner response affect learner satisfaction?

a) How do the different forms of kinetic energy (degree-based, closeness-based, and betweenness-based) change from mid-semester to the end of the semester?

b) How do the different forms of potential energy (degree-based, closeness-based, and betweenness-based) change from mid-semester to the end of the semester?

4) How does learner prior experience moderate/mediate the relationships of momentum, force and/or energy with learner satisfaction?

5) How does learner prior satisfaction moderate/mediate the relationships of momentum, force and/or energy with learner satisfaction?

Study Design

This study was an investigation into how asynchronous communication patterns of online discussion boards affect the satisfaction of adult learners. This study was a correlation design. Momentum, force, and energy parameters (which were used to construct communication patterns) were the main predictor variables and learner satisfaction was the outcome variable. Additional mediator and moderator variables such as learner prior experience and learner prior satisfaction were included in the examination to insure a balance between precision and parsimony in the learner satisfaction model.

Sampling Design

Ten groups of undergraduate and graduate students, each in separate online courses at a mid-western university were included in the study. Using a voluntary learner satisfaction survey, which was electronically distributed to the students, it was conservatively estimated that approximately ten to twelve online courses should provide a reasonable sample size of 100 responses. All information was extracted from two sources: (1) discussion board text and (2) online learner satisfaction survey, which was given near the end of the sixteen-week semester. Therefore, all data were collected at the end of the semester, and analyzed immediately afterwards. All data were linked via learner into (1) one SPSS database for statistical analysis and (2) one learner matrix in an Excel spreadsheet (or flat data file) for SNA.

As a sample whole, 102 learners had permitted parametric testing, assuming a normal distribution. However, because there were approximately ten to twenty students in each course, this required non-parametric statistics for some analyses that might need to focus on sub-samples of the main sample. The online courses used in this study had small numbers of students, which can make inferential analysis difficult, due to small sample sizes ($N < 30$). Small sample sizes increased sampling error and reduced statistical power (i.e., increases Type II error), which made the detection of effects difficult. It had the potential to reduce the reliability (i.e., internal consistency) of data on the learner satisfaction form.

Generic identification numbers were assigned to each student after all of the data had been collected so as to conceal and protect their identity. All data that contained any learner identity will be destroyed within three years of final collection: (1) paper products through shredding and combustion, and (2) electronic files through electronic scrambling and erasure from hard drive.

Data Collection

The following data were collected in order to complete this study: (1) time of discussion board postings, (2) number of words in each message, (3) name of learner for each posting (only for linking the data initially, this was removed upon completion of the dataset and its link to the learner satisfaction survey), (4) position of each discussion board posting with respect to thread and forum, (5) overall learner satisfaction, (6) demographic information, and (7) information on mediator or moderator variables (as mentioned at the beginning of the chapter).

The following steps were taken during the data collection phase:

1) Permission to collect data from the department and school in question.

2) Approval by five-member dissertation committee.

3) Approval by Institutional Review Board (IRB) at the University of Wisconsin - Milwaukee (UWM).

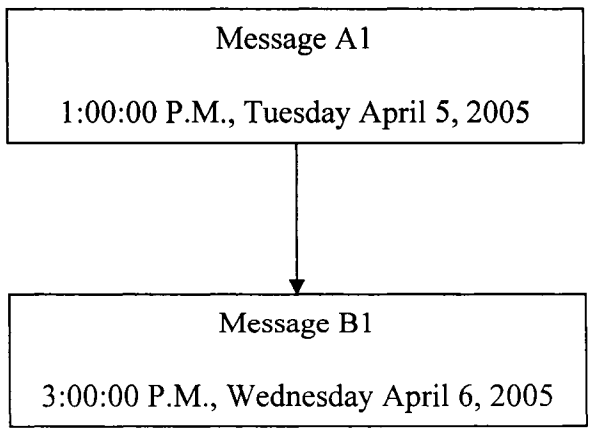
4) Electronic notification to learners via e-mail and announcement through the learner management system interface for participation in research and security measures taken to maximize protection of learner identity.

5) Follow-up response to item 4 two weeks later.

Below is a description of how each parameter was measured and how they were used to develop the communication constructs such as momentum, force, and energy (i.e., predictor variables) as well as the outcome variable of learner satisfaction.

Time of Discussion Board Postings

In this study, it was the artificial metric of physical time that was measured in order to help determine key parameters of this study: momentum, force, and energy. Each discussion board posting had a timestamp associated with it that was presented with each message.



The parameter of time that was needed for this study was the amount of time between discussion board postings. Therefore, the parameter of time was determined by subtracting the timestamp of a previous, but directly connected posting from the one in question. For example, to determine the amount of time it takes to respond to a message, consider the hypothetical timestamps of messages A1 and B1.

The amount of time it takes for message B1 to be posted with respect to message A1 is 26.00 hours. In this study, the value of 26.00 hours would be the time used for the calculations of momentum, force, and energy, not the actual time that the timestamps are made for each message. Care was taken to insure that the message being linked to on the discussion board was the message actually being responded to. In some cases, learners had posted a response to different messages than they were actually responding to.

Number of Words in Each Message

The number of words in each message was determined by electronically copying and pasting each message into Microsoft Word 2003 and using the correct menu option to count the number of words. The number of words in a discussion board posting was used as a direct measure of mass to help calculate the momentum, force, and energy (described later).

Name of Learner for Each Posting

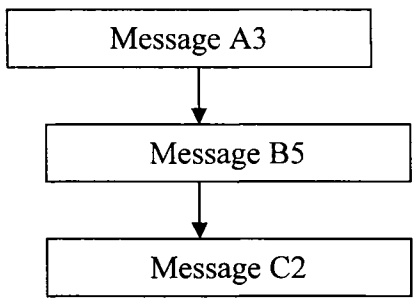
Initially, it was necessary to know which learner posted which message on the discussion board. This information was presented along with each message and timestamp.

When all of the data were collected in this study, the names of learners were replaced with generic identification numbers to protect their identity. No permanent paper and/or

electronic record of these data included the names of the learners. Any paper record was mechanically shredded and subjected to combustion. Electronic records were encrypted during the time of analysis, and subjected to electronic scrambling and destruction upon completion of the study. Every effort was made to insure the confidentiality and protection of the identities of all learners.

Position of Each Discussion Board Posting with Respect to Thread

In order to determine the parameter of distance, it was necessary to know the position of each discussion board posting with respect to the thread it was in. Therefore, the thread was electronically copied into UltraEdit 12 (a sophisticated text editor) so that the positions of each message with respect to each other were structurally maintained. This maintained the connections of the learners who electronically communicate with each other. However, in and of itself, this was often misleading. Consider the three messages:



In this example, the letters A, B, and C refer to the learners and the number to the right of the letter is simply the number of that learner's message. From the structure of the thread, it is not possible to determine if learner C is directly responding to learner B or learner A (although it gives the impression it does from the way the messages are

structured within the thread). The message itself must be read in order to determine which learner (A or B) that learner C was responding to. However, the structure of the thread helps minimize the amount of work necessary to do this. This information is useful since it can be quantified by determining the number of connections each learner has with each other learner.

Instrumentation

Overall Learner Satisfaction: Reliability and Validity

Recently, Wang (2003) concluded that the measurement of learner satisfaction in asynchronous electronic systems had not been developed into a factorable, reliable, and valid multi-component item. Wang combined components of learner satisfaction from previous reports and developed a form of learner satisfaction that factored his data into four factors (learner interface, learning community, content, and personalization), had a high degree of reliability (internal consistency, coefficient alpha = 0.93) and good validity (content, concurrent, discriminant, and convergent). Outside of any unknown forms developed "in-house," this appeared to be a form in which the format in part met the needs of this study. However, based on Wang's objectives of designing a multi-item form that associated the specific outcome of learner satisfaction with any particular independent variable of a researcher's choice, it was concluded that his form be refined to more tightly focus on communication patterns. Of the four factors in Wang's article, "learning community" most closely resembled the predictor variable of this study, and was used as a guide for developing a new learner satisfaction form.

Overall learner satisfaction was determined by a reliable multi-item, multi-factor survey form, which was electronically distributed to learners through a learner

management system at the end of the academic semester. The form retrospectively assessed multiple items of learner satisfaction at two points in time during the semester (mid-semester and the end of the semester). Retrospective analysis provided information on the change in learner satisfaction over the course of the semester.

Development of the form required that the content be checked for clarity, coherence, and completeness by discussing the components of learner satisfaction with academic faculty, colleagues, and students. A form that effectively exhausts all possible items of learner satisfaction that are linked to communication patterns will improve the content and face validity. Content validation helped meet the qualitative aspects of construct validity, which is often the least understood and addressed form of validity.

The learner satisfaction survey consisted of three major sections: (1) background information of the learner, (2) items that affected the learner's ability to participate in the course, and (3) discussion board evaluation. The first section on background information asked for demographic information (gender, race, age range, and student status) as well as the number of online courses the learner participated in, how successful they were in those courses and the grade they expected in their current course. It also asked them how much time they spent on the course and on certain aspects of communication (discussion boards, e-mail, chat rooms, and instant messaging).

The second section was broken up into three parts. The first part of the second section asked the learners to rate five items on a seven-point Likert scale (1=strongly negative, 4=neutral, 7=strongly positive) that addressed their interest, satisfaction and success with online courses. The second part of this section asked the learners to rate eight items on a five-point Likert scale (1=none, 3=a small amount, 5=a large amount) that affected their

ability to participate in the course such as time, personal energy, motivation, amount of homework, and encouragement/support). The third part of this section asked the learners to rate six items on a seven-point Likert scale (1=interfered a lot, 4=had no effect, 7=helped a lot) that affected their ability to participate in the course such as their job, social life, other courses, computer skills, writing skills, and communication skills). The third and last section consisted of 25 items on learner satisfaction that dealt specifically with online discussion boards and one item on whether the student would like to use the discussion boards in their next course. All items in this section were rated retrospectively for mid-semester and at the end of the semester. The items addressed whether the learner had enough time to participate on the discussion boards, if they were able to post enough messages, and if the messages were long enough and of suitable quality. It also asked the learner to rate the discussion boards in maintaining their interest and if they were a good use of time.

The form was pilot-tested to check for internal consistency using SPSS 14.0 to calculate Cronbach's alpha. Concurrent validity was addressed by the correlation between the total scores on the instrument (sum of all items) and a single-item overall learner satisfaction score. Comparing the scores calculated from the multi-item survey with a single-item satisfaction score determined by the learner validated the satisfaction scores (Elliott & Shin, 2002). It was not possible due to limitations in resources to test the form at two times during the semester to improve the test-retest reliability through correlation of the items across time. This would have been particularly relevant for this study, since results would be retrospectively compared at two points in time in the

semester to illustrate the laws of the conservation of momentum and the conservation of energy. A high correlation of the forms across time would insure a stable instrument.

Since this study used more than one communication construct developed from the physical parameters in physics (momentum, force, and energy), the items of learner satisfaction clustered. Exploratory factor analysis (Doll, Raghunathan, Lim, & Gupta, 1995) revealed which items converge and diverge and therefore revealed the levels of convergent and divergent validity of the collected data. It was anticipated that at least three clusters would manifest themselves based on learner satisfaction items associated with momentum, force, and energy.

The construction of the overall learner satisfaction form was necessary based on limitations in the literature (Wang, 2003). The literature provided for instruments in learner satisfaction and communication satisfaction, but not a combination of the two items. The content and construct validity of the form was improved when the outcome variable was based on multiple items that were based on communication patterns. The multiple-item survey form was based on the weighted gap score analysis approach developed by Elliott and Shin (2002) and the Communication Satisfaction Questionnaire created by Downs and Hazen (1977) and revised by Gray and Laidlaw (2004) which are briefly described below.

Many measurements of learner satisfaction treat it as a unidimensional construct, which sometimes can ignore the complexity of the phenomenon. Recently, Elliott and Shin (2002) developed a weighted gap score analysis approach using multiple items to improve the diagnostic value of the learner satisfaction measurement. While the study from Elliott and Shin focused on learner satisfaction from a general perspective, the

statistical approach was applied to this study in the narrower context of asynchronous communication.

The literature had several instruments for measuring communication satisfaction, but one of the most comprehensive instruments comes from Downs and Hazen (1977) called the Communication Satisfaction Questionnaire. The 40-item instrument was developed for assessing communication satisfaction in the workplace. However, it has been used by a wide number of researchers in many different areas such as a health care organization (Fitzgerald & Desjardins, 2004), a certified public accounting firm (Gregson, 1991), and an engineering/manufacturing firm (Crouch & Hellweg, 1989), which suggests its robustness. It has a reliability of 0.94 (Greenbaum, Clampitt, & Willihnganz, 1988), and recently Gray and Laidlaw (2004) recently reexamined its psychometric properties. A series of one-factor measurement models substantiated the validity of the factors. The study identified a second-order factor structure consisting of informational and relational communication that was empirically superior to competing models.

Mediator and Moderator Variables

Since learner satisfaction is a complex variable, it was assumed that some mediator and moderator variables needed to be investigated parallel to the communication constructs. Based on the literature review in chapter II, it was concluded that the asynchronous communication learner satisfaction model will be more precise and help contribute information to the somewhat contradictory literature on learner satisfaction in online courses as partially delineated in Thurmond (2003). However, there were suspicions that some of these variables such as learner characteristics would not significantly contribute to the variability of the study based on conflicting reports in the

literature. It was necessary to ultimately remove some of these variables to create a more parsimonious model. The following model depicted in Figure 3-1 helped account for mediator and moderator variables that impacted learner satisfaction within the context of this study. The outcome variable and the main predictor variables are in rectangles, while the mediator and moderator variables are in ellipses.

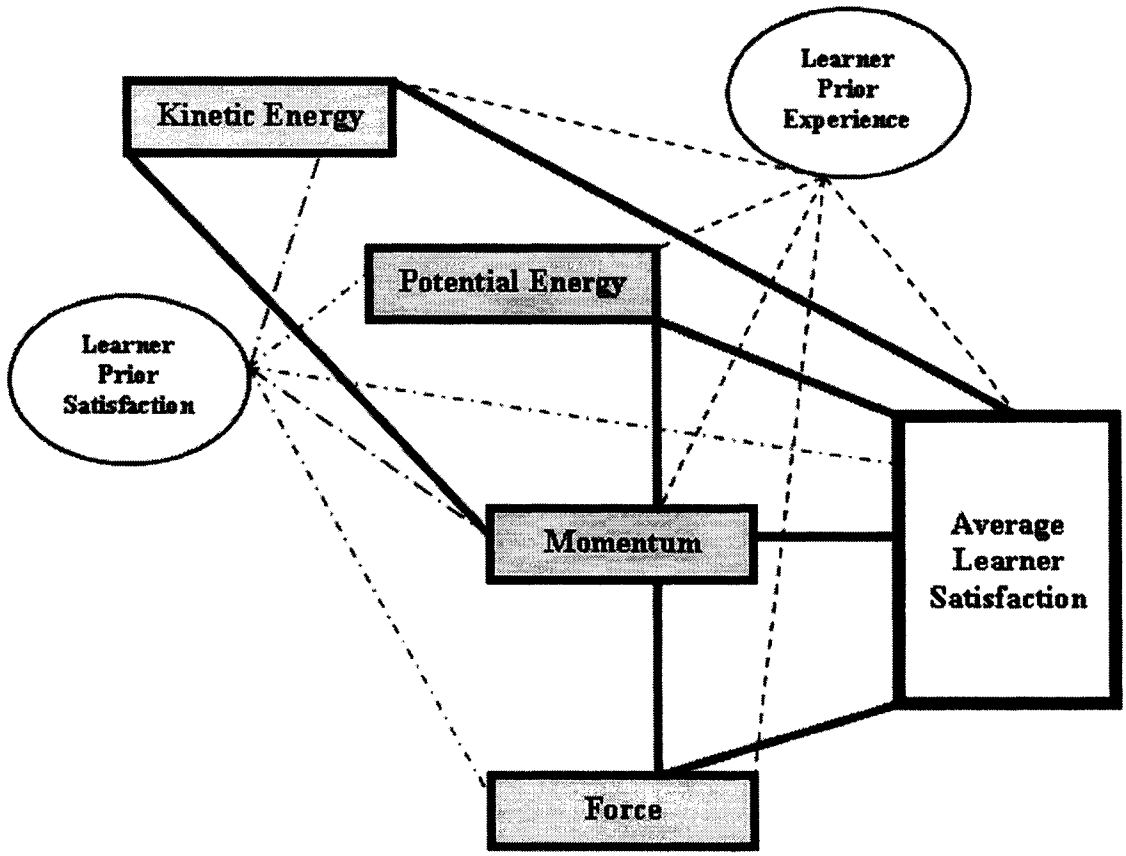


Figure 3-1: Model for Asynchronous Communication Patterns and Learner Satisfaction

One of the more debatable moderator variables in this model was learner prior experience. Thurmond (2003) classified this as an input variable using Astin's (1993) I-E-O model and reported that it did not significantly contribute to her regression model with learner satisfaction as the outcome variable. While some prior research agreed with

that assessment (Shea, Frederickson, & Pickett, 2000), some did not (Atack & Rankin, 2002; Vrasidas & McIsaac, 1999). It was believed that learner prior experience with online education will affect a learners momentum and energy and hence learner satisfaction. In the flow diagram, learner prior experience is a moderator variable for momentum and energy. Another variable that needed further exploration was learner prior satisfaction. While it may seem intuitive that satisfaction with a prior online experience would lead to satisfaction with a current online experience, the literature seemed somewhat vague (Arbaugh, 2000; Navarro & Shoemaker, 2000).

Data Analysis

Communication Constructs: Momentum, Force, and Energy

The following data which were listed above were used to create the communication constructs of momentum, force, and energy: (1) time of each individual discussion board postings, (2) number of words in each individual message, (3) name of learner for each posting, and (4) position of each discussion board posting with respect to thread and forum. The use of kinetic and thermodynamic parameters from the natural sciences to describe text has already been reported (Tonfoni, 1996). In this study, the derived kinetic parameters of momentum and force (which are constructed from the fundamental parameters of time, mass, and distance) and the thermodynamic parameter of energy (constructed from the same fundamental parameters) was used to develop the model of this study.

Momentum

Momentum (p) depends on the mass (m) and speed (v) of an object as seen in equation 1A. Mass and velocity are directly proportional to the calculated value of momentum.

Note that under normal circumstances, the mass of an object does not change. Therefore, to change the momentum of an object requires a change in velocity.

Equation 1A: momentum = (mass) x (velocity)

Equation 1A is expressed symbolically as:

Equation 1B: $p = m \cdot v$

However, speed is derived from dividing distance (d) from time (t) and equations 1A and 1B become equations 2A and 2B, respectively. There is a directly proportional relationship between momentum and mass as well as momentum and distance, but an inversely proportional relationship between momentum and time (Wolfson & Pasachoff, 1995).

Equation 2A: momentum = [(mass) x (distance)] / [time]

Equation 2A is expressed symbolically as:

Equation 2B: $p = m \cdot d / t$

In order to see the relationships of the three fundamental parameters (mass, distance, and time) and the derived kinetic parameters (momentum and force) in physics and as communication constructs in this study the reader should refer to the first section of this chapter and consult Table 3-1. The definitions were derived from Tonfoni (1996), the Hyperdictionary (2006) and social network theory (Wasserman & Faust, 1994). The mathematical and conceptual relationships that exist between momentums in the natural sciences have been extrapolated to the social sciences (Tonfoni, 1996; Plaud & Gaither, 1996).

Table 3-1

Fundamental and Derived Kinetic Parameters

Parameter	Symbol	Meaning as Physical Parameter	Meaning as Communication Construct
Fundamental			
Mass	**m**	Amount of matter in an object	Number of words in a text posted by learners
Distance	**d**	How far an object travels	How far learners are from one another in a social network (based on their text postings)
Time	**t**	Duration an object travels	Duration between text messages posted by learners
Derived			
Momentum	**p**	Impetus of a physical object in motion	Impetus of a nonphysical process, such as an idea expressed in text
Force	**F**	A quantity that tends to change the momentum of an object	A capacity to change momentum (e.g., posting to the discussion board)

In physics, the mass is considered to be the amount of matter that an object will possess, while the distance is how far an object moves and the duration of how long it takes the mass to move in that distance. In this study, the communication constructs equated the mass of an object to the number of words are in a single text message. The distance was determined by social network analysis and is an aggregate value of how close the learners are with respect to each other through analysis of their text messages. The meaning and construction of the distance value will be further explained later in this chapter. The time was the duration that passes between two messages and was associated directly with the respondent's message. The values of mass, distance, and time were used to determine the momentum (through equation 2A) that an individual learner had at the time that they posted the message on the discussion board.

Force

In order to change the momentum of an object, the net external force (F) imparted to the object must change its momentum. The magnitude of the net force can be determined quantitatively by determining changes in momentum. If the net force is applied for greater lengths of time, the change in momentum will be greater. A force applied across time, which imparts a change in the momentum of an object, is called an impulse (J):

Equation 3A: Impulse = Force x Time = Change in Momentum

Equation 3B: $J = F \cdot t = \Delta p$

The identity of such forces was identified qualitatively by the learner satisfaction survey. Learners were asked to identify any forces that may have impacted their ability to maintain a constant momentum throughout the course. Naturally positive forces (e.g., interest, motivation, etc.) increased the momentum over time (Δ p is positive), and negative forces (e.g., attrition, apathy, etc.) decreased the momentum over time (Δ p is negative).

The significance of external forces was checked through a dependent t-test of mid-semester momentum versus end-of-semester momentum. This was done on a learner-by-learner basis and for the class.

Correlation of mid-semester momentum and end-of-semester momentum checked to see if learners maintained the same relative momentum across the two quarters with respect to the class. Correlation of mid-semester momentum, end-of-semester momentum, or overall momentum with learner satisfaction was also determined. Since it was hypothesized that changes in the consistency and abundance of discussion in online

discussion board threads will impact learner satisfaction in online courses, then it followed that learners with higher levels of momentum would be more satisfied, while learners with lower levels of momentum would be less satisfied.

Since significant changes in momentum occurred, the magnitude of the net force was correlated with learner satisfaction. It was hypothesized that changes in the consistency and abundance of discussion in online discussion board threads would impact learner satisfaction in online courses. Therefore, more positive values of net force yielded higher levels of learner satisfaction, while more negative values of net force yielded lower levels of learner satisfaction.

Energy

Kinetic energy (K), like momentum, depends on the mass (m) and speed (v) of an object, as illustrated in equations 4A and 4B:

Equation 4A: kinetic energy = (1/2) x (mass) x $(\text{velocity})^2$

Equation 4A is expressed symbolically as:

Equation 4B: $K = 1/2 \cdot m \cdot v^2$

It is necessary to illustrate how the derived thermodynamic parameter of kinetic energy (K) is calculated from the fundamental parameters of time (t), mass (m), and distance (d), as indicated in equations 5A and 5B:

Equation 5A: kinetic energy = ½ x (mass) x $[(\text{distance} / \text{time})]^2$

Equation 5A is expressed symbolically as:

Equation 5B: $K = ½ \cdot m \cdot (d / t)^2$

The relationship between potential energy (U) and the fundamental parameters of mass (m), acceleration due to gravity (g), and height (h) is indicated in equations 6A and 6B:

Equation 6A: potential energy = (mass) x (gravitational constant) x (height)

Equation 6A is expressed symbolically as:

Equation 6B: $U = m \cdot g \cdot h$

The parameters of the gravitational constant and height and the derivation of potential energy need explanation. In physics, all masses accelerate towards each other due to the gravitational force. If the objects are very close or at the Earth's surface, the acceleration is fixed at 9.8 meters per second squared. The height of the object is simply the shortest distance from the object to the Earth's surface.

Creating communication constructs for the gravitational constant and the height is conceptually difficult, and the mass of an unknown object (i.e., a text message that hasn't actually been posted) can only be predicted. Therefore, the potential energy will be predicted from the missing kinetic energy via the conservation of energy. The conservation of energy states that energy cannot be created nor destroyed. If no other energies are present, the two forms of energy should sum to a constant value.

Kinetic energy is the energy of text as it is moving down the discussion board. Potential energy is the untapped (i.e., potential) energy, which manifests itself as text that has little or no responses to it. As people respond to text more often, the kinetic energy will increase, and the potential energy decrease. In other words, text that is not being responded to does not allow the learner who posted it to reach the other learners. That is, the message that does not get many responses does not reach the other learners. In order

to see the relationships of the three fundamental parameters (mass, distance, and time) and the derived thermodynamic parameters (kinetic and potential energy) in physics and as communication constructs in this study the reader should consult Table 3-2.

Table 3-2

Fundamental and Derived Thermodynamic Parameters

Parameter	Symbol	Meaning as Physical Parameter	Meaning as Communication Construct
Fundamental			
Mass	**m**	Amount of matter in an object	Number of words in a text posted by learners
Distance	**d**	How far an object travels	How far learners are from one another in a social network (based on their text postings)
Time	**t**	Duration an object travels	Duration between text messages posted by learners
Gravitation Constant	**g**	Acceleration due to gravity	----------
Height	**h**	Distance from the surface of the Earth	----------
Derived			
Kinetic Energy	**K**	Energy of motion for an object	Energy of motion for text
Potential Energy	**U**	Energy of position for an object (untapped energy)	Untapped energy of text

Therefore, for each discussion board thread, all posters and non-posters were identified. The posters had kinetic energy that was easily determined through equations 4A or 4B. If every learner posted to every thread, all energy would be in the form of kinetic energy. In this situation, the total kinetic energy would be the total energy. This is analogous to a falling object that strikes the earth. At the point of impact, all potential energy of the falling object is gone (i.e., the height is zero), the kinetic energy is at a maximum, and kinetic energy equals total energy. Conversely, if a message is never

responded to by other learners, all of the energy would be in the form of potential energy, much like an object that is about to be released and fall to the Earth.

The missing kinetic energy could be predicted by using an average value of mass and time for each learner and his/her distance value from SNA. That way, the percentage of kinetic energy for each discussion board thread could be determined. The remaining percentage from one hundred percentage points would be the predicted potential energy.

At first glance, the conservation of energy investigation might seem to be addressing the same issue as the conservation of momentum investigation because of the same parametric dependence of momentum and kinetic energy. However, the conservation of momentum is based on the premise that learners have momentum because they participate in the discussion boards. This momentum will change if external forces are present. This naturally assumes that there is participation and that it may or may not change significantly. The conservation of energy is based on the premise that there could be more participation by each of the learners. In effect, the conservation of momentum focuses on what is present (by way of momentum) and how it may change (by way of external force); while the conservation of energy will focus on what could be present (by way of potential energy).

Correlation of the percentage of kinetic energy to learner satisfaction will determine the association of these two variables. It was hypothesized that greater percentages of kinetic energy will yield higher levels of learner satisfaction, while lower percentages of kinetic energy will yield lower levels of learner satisfaction.

Multiple regressions were used to predict the variance of learner satisfaction, based on linear combinations of momentum, force, and ratio of kinetic energy. It established the

relative predictive importance of the independent variables (by comparing beta weights), which illustrated what impacts learner satisfaction the greatest: participation, rate of participation, or rate of change of participation on the discussion boards.

Multi-factor analysis of variance (ANOVA) would indicate if there was a significant difference in learner satisfaction for learners with different levels of momentum, different rates of change of momentum, and the interaction between the two variables.

Social Network Analysis: Matrix and Graphical Analysis

There are two formal mathematical tools that are used in SNA: matrix and graphical analysis. The structure of the data matrix is described below. Once data are collected, they are analyzed using matrix algebra and graph theory. If a pattern of social relations or ties among a set of actors has been represented in a formal way (matrices or graphs), then important ideas about social structure can be defined.

A matrix is a rectangular arrangement of a set of elements. In SNA, the number of elements in the columns (i) is equal to the number of elements in the rows (j), which results in a square matrix ($i=j$). Mathematical operations that apply to rectangular matrices automatically apply to square matrices (i.e., since a square is a special form of rectangle). Many of these operations are familiar to researchers who use multivariate statistical techniques (e.g., multivariate analysis of variance [MANOVA]). Social network analysts use a variety of mathematical operations on the matrices (e.g., matrix addition and subtraction, transposes, inverses, matrix multiplication, determinants, eigenvalues, vectors, etc.). Using these basic operations, statistical techniques can be applied to the data (e.g., matrix correlation and regression) (Schott, 1996).

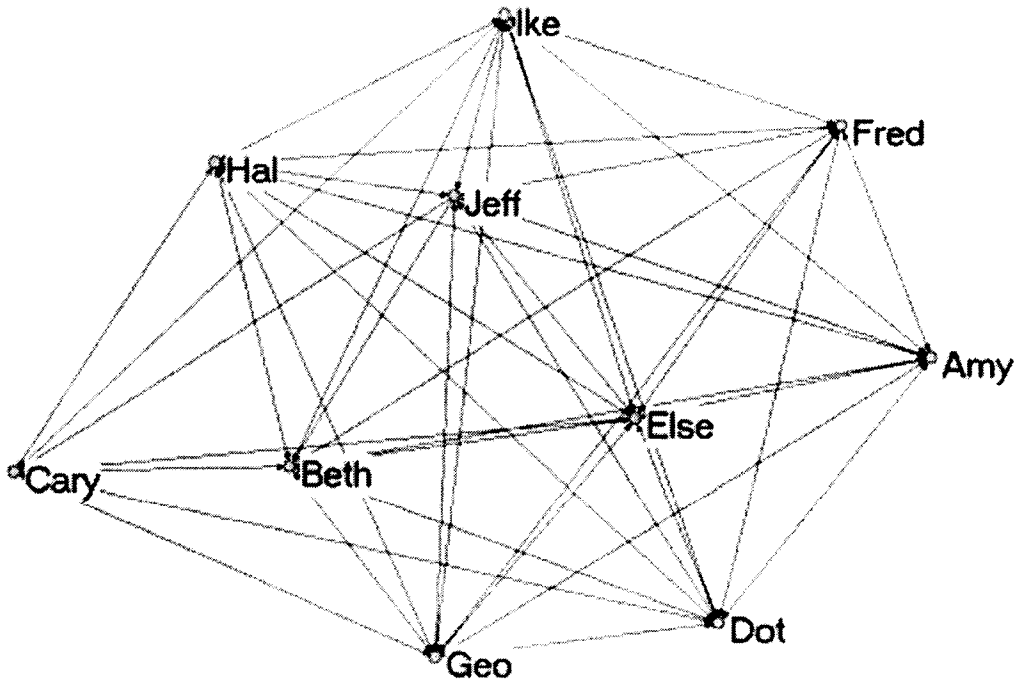


Figure 3-2: Socio-gram of data in Table 5.

Figure 3-2 is a socio-gram, which is a graphical representation of the data from Table 3-3. The diagram was generated with a SNA computer program called UCINET 6 (Borgatti, Everett, & Freeman, 2002). The nodes are labeled with the learner's name, while the links are represented by lines with arrows to indicate the direction of communication. That is to say, lines with arrows on both ends indicate bi-directional communication, while lines with one arrow indicate unidirectional communication with the arrow pointing towards the person who was written to.

Basic Properties of Networks and Actors

Differences in how individuals are connected within their network aid researchers in understanding their attitudes and behavior. The number of connections between actors may be an indication of the degree of influence that particular individual in a network has over the other members or experiences from them. The number of connections an actor

has may indicate the rate of transfer of information to other members throughout the network. Basic individual or network characteristics such as size, density, or degree will grant insight into more abstract characteristics such as reciprocity, flow, influence, etc.

Table 3-3

Messages from Ten Participants in a Discussion Board

		Learner who Posted Original Message ("Sink")										
		Amy	**Beth**	**Cary**	**Dot**	**Else**	**Fred**	**Geo**	**Hal**	**Ike**	**Jeff**	**Total**
Learner who Posted a Response ("Source")	**Amy**	-----	12	0	6	5	4	6	8	4	4	**49**
	Beth	12	-----	2	6	5	2	6	4	3	0	**40**
	Cary	0	4	-----	8	4	0	5	4	3	0	**28**
	Dot	8	6	10	-----	5	0	1	8	4	2	**44**
	Else	7	6	0	0	-----	6	4	5	3	6	**37**
	Fred	3	0	0	4	4	-----	5	9	4	8	**37**
	Geo	2	2	2	3	3	6	-----	8	4	4	**34**
	Hal	5	5	1	1	3	0	6	-----	3	5	**29**
	Ike	4	3	0	1	3	5	2	5	-----	2	**25**
	Jeff	4	1	2	6	4	10	6	0	4	-----	**37**
	Total	**45**	**39**	**17**	**35**	**36**	**33**	**41**	**51**	**32**	**31**	**360**

As a way to illustrate these concepts, consider the set of data (Table 3-3) with ten learners that are participating in an online course. Again, the names of the individuals will be listed along the rows and columns. In this case, the outcomes will be the number of discussion board postings a learner makes to another learner in the course during the semester. Those learners who posted the original message, called sinks, are listed as columnar headings. Those students who responded to another student's message, called sources, are listed along the row headings.

Matrix Analysis: Centrality and Variability

Summary information is given in Table 3-3 to indicate the strongest posters and responders. The relationships between learners are called ties in SNA. Those learners who posted the original messages are those learners who are waiting for a reply from another learner and are "sinks" of ties (i.e., information moves towards them). The

learners who post responses to these messages are called "sources" (i.e., information moves away from them), but become potential "sinks" for someone who will respond to their post. The sum of the connections from the learner to others is called the "out-degree" of the point, while the sum of connections to a given learner from the others is called the "in-degree." The number and kinds of ties that learners have are a basis for similarity and differences to other learners, and therefore subject to differentiation and stratification.

The ratio of "out-degree" to "in-degree" messages is an indication of the parity (or disparity) of the interaction of learners in the network. It has been referred to as an S-R ratio (i.e., messages Sent / messages Received). As the ratio becomes larger than unity, the learners behave more like sources, and as the ratio decreases from unity towards zero, they behave more like sinks. Ratios that are close to unity have higher degrees of parity, while ratios far from unity, have higher degrees of disparity.

The first thing to notice from the data is the total scores. Amy was the highest-ranking source with a total of 49 postings, while Hal was the highest-ranking sink with 51 postings. This suggests that Amy reacted to other learner's messages in the greatest amount and was influenced by the material on the discussion board more than anyone else did. It could also be seen as an attempt to have influence over other learners herself. Conversely, Hal seemed to have the greatest influence on the class, since more people responded to him than anyone else. These two positions indicate that the two learners may possess a higher degree of centrality in the network, and consequently the most power, influence, and reach.

Univariate statistics can be generated for the data as in traditional sociological data. In Table 3-4, the total, mean, and standard deviation are given for each learner and their roles as both source and sink.

Table 3-4

Univariate Statistics of Sources and Sinks

Learner	Source		Sink		S-R Ratio
	Mean (SD)	Total	Mean (SD)	Total	
Amy	5.4 (3.3)	49	5.0 (3.6)	45	1.09
Beth	4.4 (3.5)	40	4.3 (3.6)	39	1.03
Cary	3.1 (2.7)	28	1.9 (3.2)	17	1.65
Dot	4.9 (3.4)	44	3.9 (2.8)	35	1.26
Else	4.1 (2.6)	37	4.0 (0.9)	36	1.03
Fred	4.1 (3.1)	37	3.7 (3.5)	33	1.12
Geo	3.8 (2.0)	34	4.6 (1.9)	41	0.83
Hal	3.2 (2.2)	29	5.7 (2.9)	51	0.56
Ike	2.8 (1.7)	25	3.6 (0.5)	32	0.78
Jeff	4.1 (3.0)	37	3.4 (2.7)	31	1.19
Total	40.0 (9.1)	360	40.0 (7.4)	360	1.00

While mean and total scores will give an indication of centrality and therefore power, influence, and reach, the standard deviation is evidence for variability. Those learners who are sources with lower standard deviations (i.e., lower variability) will respond to the other learners more evenly, while those with higher standard deviations (i.e., higher variability) will be more discriminating in whom they respond to. Likewise, those learners who are sinks with lower standard deviations will have learners more evenly respond to them, while those with higher standard deviations will have certain learners respond to them more often than other learners do. Responding to a greater number of learners increases the reach (and distance) of a given learner.

Matrix Analysis: Distance

There are some basic parameters in SNA, which deal primarily with adjacencies (direct connections) between learners (e.g., density - the proportion of all ties that could be present that actually are). However, the way that people are embedded in networks is more complex than this. If two learners are adjacent, the distance between them is one. If A tells B, and B tells C (and A does not tell C), then learners A and C are at a distance of two. Those learners who are less distant to many others may be able to exert more power and influence than those who are more distant may. Network analysts are more likely to describe their approaches as descriptions of centrality than of power. Depending on what's most appropriate, centrality can be described by degree, closeness, and betweenness.

Degree-based distance is a measure of how many direct ties (links) a learner has with other learners in the class, and thus reflects the number of choices and opportunities to communicate with other learners. Therefore, the degree-based distance of a learner indicates the extent to which a learner may be constrained by, or constrain other learners (Hanneman & Riddle, 2005) by the number of direct connections to other learners. In essence, degree-based distance is a measure of power, since the more direct ties a learner has, the more reach and power s/he has (Bonacich, 1987).

Unlike degree-based distance, closeness-based distance doesn't have the limit of considering only direct ties to other learners, as it considers all learners in the network. Closeness-based distance measured how easily and therefore how quickly a learner can access all other learners through text messages on the discussion boards as a result of a learner's position in the network. Access to other learners in the network gave an

individual access to new information and the ability to create and share knowledge (Cross, Parker, Prusak, & Borgatti, 2001). Location in the network is an aspect of structural advantage, since being "closer" to other learners in the network than others are to each other, gives an individual more influence and power.

Betweenness-based distance measures how often the learner is on the path between other learners. In other words, the control a learner has over the text that flows on the discussion boards between two other learners. Betweenness-based distance demonstrates the ability of a learner to broker information and control communication between other learners (Zemljič & Hlebec, 2005; Freeman, 1979), and that by removing him/herself from the network, the learner potentially disrupts the flow of information.

Summary of Descriptive and Inferential Statistics

Core (Parsimonious) Model

The most parsimonious model for this study only included the outcome of learner satisfaction and the predictors of momentum, force, and energy. The statistical analyses associated with this model are listed in this section first. The more precise model, which includes the additional mediator and moderator variables are listed in the next section.

The first analysis included descriptive statistics (central tendency, variability, skew, kurtosis, frequencies) regarding the sample. Information included demographic variables (gender, learner status, race, age range, experience with online courses and discussion boards, etc) as well as items from the learner satisfaction form. The use of descriptive statistics characterized the sample and scanned for errors.

The second analysis included inferential statistics to compare overall and average learner satisfaction at mid-semester and at the end of the semester.

The third analysis was a reliability analysis used to determine internal consistency of the learner satisfaction form via Cronbach's alpha. Internal consistency was determined for sections II-A, II-B, II-C, and III (mid-semester and end of semester).

The fourth analysis was an exploratory factor analysis of section III of the learner satisfaction form. Exploratory factor analysis helped reveal which items correlated within and across factors to reveal the levels of convergent and divergent validity of the collected data. Correlations of factors revealed if they were measuring the same overall attitudinal construct of learner satisfaction.

The fifth analysis included descriptive and inferential statistics of word counts (mass) rate of response (time) and mass/time ratios.

The sixth analysis was the social network analysis of the discussion board postings. This required the creation of a social network matrix from the original data matrix. Once the links between learners had been input in the social network matrix, the derived values of distance (degree, closeness, and betweenness) were obtained from analysis and used for the creation of communication constructs of momentum, force, and energy. Mass, time, and distance were used to create the communication constructs of momentum, force, and energy as described earlier.

The seventh analysis included the use of descriptive statistics to report the centrality and variability of momentum, force, and energy done for mid-semester (first eight weeks), end-of-semester (entire semester of sixteen weeks). This included the use of comparative inferential statistics (i.e., t-tests) to examine the differences of momentum across time so as to test the conservation law of momentum, and determine if external forces are causing any violation of the law.

This analysis also required the correlations of momentum across time (i.e., mid-semester to end-of-semester). The correlation of momentum across time revealed if there were consistent changes in momentum for each learner in the class. This was reported with a dependent t-test which compared the mid-semester to end-of-semester momentum values. Collectively, the correlation and dependent t-test yielded any one of four possible outcomes as reported in Table 3-5.

Table 3-5

Outcomes of Correlations and Dependent t-tests of Momentum across Time

		Statistical Significance of Correlation	
		Significant correlation ($p < 0.05$)	**No significant correlation ($p > 0.05$)**
Statistical Significance of Dependent t-test	**Significant dependent t-test ($p < 0.05$)**	No conservation of momentum for either individual learners or class overall	No conservation of momentum for class overall
	No significant dependent t-test ($p > 0.05$)	Conservation of momentum for individual learners and class overall	Conservation of momentum for class overall only

Naturally, if the conservation of momentum held from these tests, no change in net external forces should occur. However, when the conservation of momentum does not hold then the significant presence of net external forces was assumed.

The eighth analysis included correlations of momentum, force, and energy with the outcome variable of learner satisfaction. These correlations along with the correlations between the main predictor variables created the structural core model of the study.

The ninth analysis included linear regression, which was used to predict the variance of learner satisfaction, based on linear combinations of momentum, force, and energy. It established the relative predictive importance of the independent variables (by comparing

beta weights), which illustrated what impacts learner satisfaction the greatest: participation, rate of participation, or rate of change of participation on the discussion boards.

The tenth analysis included correlation and linear regression analysis of mediator and/or moderator variables used to create the high precision model of this study Mediator and moderator variables were also added to the multiple regression models for precision. Linear regression was used to examine at which point that the model was balanced between precision and parsimony.

In summary, descriptive and inferential statistics were used to assess the association between momentum, force, and energy and to learner satisfaction. Table's 3-6A to 3-6D indicated specifically which tests were used. If the sample sizes were small, the distribution was non-normal or relationships between variables were non-linear, non-parametric tests were used and were indicated as more robust, albeit less powerful alternatives for the appropriate tests in the table.

Precision Model

The more precise model for this study included the outcome of learner satisfaction, the predictors of momentum, force, and energy and the moderator and mediator variables mentioned earlier in this chapter. The statistical analyses associated with this model included the analyses presented in the parsimonious model section and those listed directly below.

Baron and Kenny (1986), and later Muller, Judd, and Yzerbyt (2005) described a framework for handling a combination of mediator and moderator variables that were adapted to this study. Since there were many possible arrangements for the variables to

have (i.e., they can potentially act as mediators or moderators), the analyses described below will be a general description for handling each situation that has one mediator variable and one moderator variable.

According to Baron and Kenny (1986), and later Muller, Judd, and Yzerbyt (2005) there are three steps for handling a model that has one independent variable (IV), one mediator variable (MedV), one moderator variable (ModV), and one dependent variable (DV).

Using Figure 3-3 as a general framework, three regression equations are needed, each adding one additional component to the previous regression. Note: These equations are not exhaustive of all possible equations, but they do account for many potential relations. Although it's assumed that a continuous scale is used for all variables in this study, it is not a necessary requirement.

The first linear regression needed in the analysis would check for how the relation between the IV and DV is a function of the ModV. In this case the DV is regressed onto three components: ModV, IV, and the interaction between them (ModV x IV). Moderator effects are indicated by the significant effect of the interaction while ModV and IV are controlled. Note: ModV should not be correlated with IV or DV to provide a clearly interpretable interaction term.

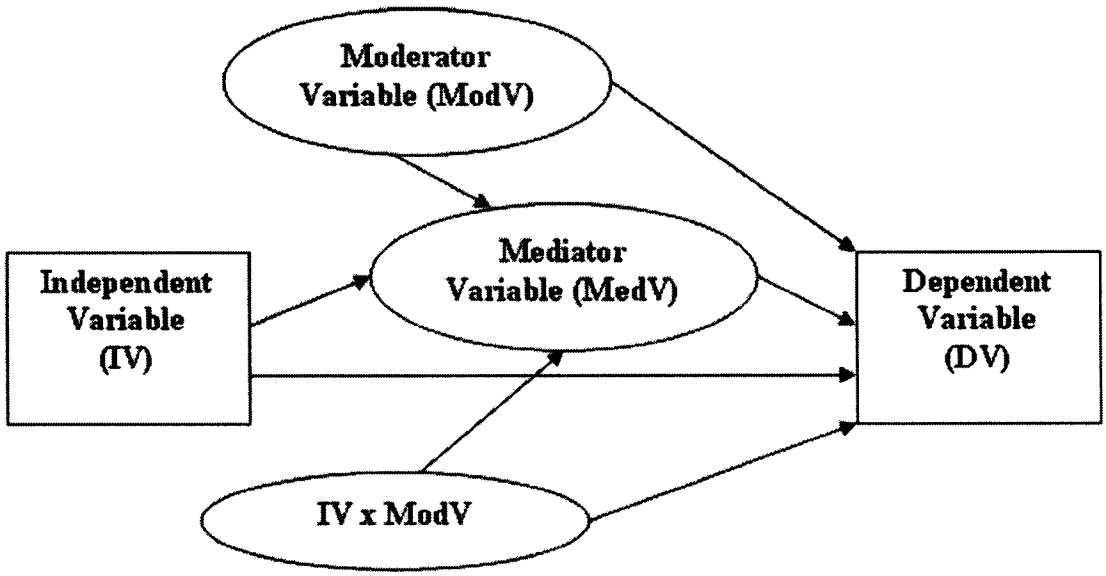


Figure 3-3: Schematic for a framework which combines one independent variable, one mediator variable, one moderator variable, and one dependent variable.

The second regression required in the analysis would check for the effect of mediation between IV and DV. This requires a regression of DV onto four components: IV, ModV, the interaction ModV x IV and MedV. For MedV to mediate the IV to DV relation, three items are necessary: (a) IV must affect MedV, (b) MedV must affect DV, and (c) when the first two relations are controlled for, the direct relation between IV and DV must decrease in strength (preferably to a statistically insignificant level).

Furthermore, it's possible that the interaction term between the moderator variable and the independent (ModV x IV) may impact MedV and DV. If the interaction term impacts DV in regression one to a greater extent than in regression two than the interpretation is that MedV has mediated the interaction term on the dependent variable. This is called mediated moderation.

The third step essential to the analysis would require a regression of DV onto five components: IV, ModV, the interaction ModV x IV, MedV and the interaction MedV x IV. The key item is checking for any reductions that occur for the interaction item ModV x IV onto the dependent variable from the second regression equation. If so, then MedV and not ModV, moderates the IV to DV relation. In other words, MedV mediates the moderating effects of ModV on IV.

Summary of Research Questions and Corresponding Statistical Analysis

Table 3-6A

Research Questions and Statistical Analysis: Momentum

Research Question	Measurement
1) How does the momentum of communication patterns in an online discussion board affect the outcome of learner satisfaction?	Descriptive statistics (means and standard deviations) on momentum and learner satisfaction.
	Correlation (Pearson or Spearman) of momentum with average learner satisfaction.
	Regression analysis of average learner satisfaction on momentum.
a) How does the learner satisfaction change from mid-semester to the end of the semester?	Dependent t-tests (or Wilcoxon sign-rank tests) on learner satisfaction from mid-semester to the end of the semester.
b) How do the individual learner satisfaction items group into larger learner satisfaction factors?	Factor analysis of learner satisfaction items.
c) How does the amount of text posted and the rate of response change from mid-semester to the end of the semester?	Dependent t-tests (or Wilcoxon sign-rank tests) on mass, time and mass/time.
d) How do the different forms of distance (degree, closeness, and betweenness) between learners change from mid-semester to the end of the semester?	Dependent t-tests (or Wilcoxon sign-rank tests) on each form of distance from mid-semester to the end of the semester.
e) How do the different forms of momentum (degree-based, closeness-based, and betweenness-based) change from mid-semester to the end of the semester?	Dependent t-tests (or Wilcoxon sign-rank tests) on each form of momentum from mid-semester to the end of the semester.

Table 3-6B

Research Questions and Statistical Analysis: Force

Research Question	Measurement
2) How does external forces change the momentum of communication patterns in an online discussion board affect the outcome of learner satisfaction? In other words, how does the change in the rate of response affect learner satisfaction?	Descriptive statistics (means and standard deviations) on force and learner satisfaction.
	Dependent t-tests (or Wilcoxon sign-rank tests) on each form of momentum from mid-semester to the end of the semester (since the change in momentum is proportional to force).
	Correlation (Pearson or Spearman) of net external force with average learner satisfaction.
	Regression analysis of average learner satisfaction on force.

Table 3-6C

Research Questions and Statistical Analysis: Energy

Research Question	Measurement
3) How does the amount of kinetic and potential energy of communication patterns in an online discussion board affect the outcome of learner satisfaction? In other words, how does the presence/absence of learner response affect learner satisfaction?	Descriptive statistics (means and standard deviations) on kinetic energy, potential energy and learner satisfaction.
	Correlation (Pearson or Spearman) of kinetic energy with average learner satisfaction.
	Correlation (Pearson or Spearman) of potential energy with average learner satisfaction.
	Regression analysis of average learner satisfaction on kinetic energy and potential energy.
a) How do the different forms of kinetic energy (degree-based, closeness-based, and betweenness-based) change from mid-semester to the end of the semester?	Dependent t-tests (or Wilcoxon sign-rank tests) on kinetic energy from mid-semester to the end of the semester.
b) How do the different forms of potential energy (degree-based, closeness-based, and betweenness-based) change from mid-semester to the end of the semester?	Dependent t-tests (or Wilcoxon sign-rank tests) on potential energy from mid-semester to the end of the semester.

Table 3-6D

Research Questions and Statistical Analysis: Mediators/Mediators

Research Question	Measurement
4) How does learner prior experience moderate/mediate the relationships of momentum, force and/or energy with learner satisfaction?	Descriptive statistics (means and standard deviations) on learner prior experience.
	Regression analysis of average learner satisfaction on learner prior experience, any one of the predictor variables and the interaction between learner prior experience and a predictor variable.
	Regression analysis of learner prior experience on any one of the predictor variables.
5) How does learner prior satisfaction moderate/mediate the relationships of momentum, force and/or energy with learner satisfaction?	Descriptive statistics (means and standard deviations) on learner prior satisfaction.
	Regression analysis of average learner satisfaction on learner prior satisfaction, any one of the predictor variables and the interaction between learner prior satisfaction and a predictor variable.
	Regression analysis of learner prior satisfaction on any one of the predictor variables.

Limitations

This study was based on a non-random group of students from various courses who had volunteered to respond to a survey, which limited its generalizability. Sample size was 102 learners, which was adequate for the use of powerful parametric statistics such as reliability ($N > 30$), but could have been slightly larger for the exploratory factor analysis ($N > 100$ and $N > 10$*(number of items)). More robust, albeit less statistically powerful, non-parametric tests were used for some analyses which made it more difficult to detect effects and increased Type II error. The collection and combination of data from more than one course increased the sample size, but made the statistical power of some inferential statistical tests decrease.

CHAPTER IV

Results

Chapter IV reports the results of this study. This includes descriptive and inferential statistics of the data, as well as the psychometric analysis of the learner satisfaction survey form.

Purpose

The purpose of this study was to examine the association of asynchronous communication patterns from online course discussion boards and learner satisfaction. The five principal research questions and their sub-questions that this study addressed were as follows:

1) How does the momentum of communication patterns in an online discussion board affect the outcome of learner satisfaction?

a) How does the learner satisfaction change from mid-semester to the end of the semester?

b) How do the individual learner satisfaction items group into larger learner satisfaction factors?

c) How does the amount of text posted and the rate of response change from mid-semester to the end of the semester?

d) How do the different forms of distance (degree, closeness, and betweenness) between learners change from mid-semester to the end of the semester?

e) How do the different forms of momentum (degree-based, closeness-based, and betweenness-based) change from mid-semester to the end of the semester?

2) How do external forces, which change the momentum of communication patterns in an online discussion board, affect the outcome of learner satisfaction? In other words, how does the collective change in amount of text posted, the rate of response and distance to other learners affect learner satisfaction?

3) How does the amount of kinetic and potential energy of communication patterns in an online discussion board affect the outcome of learner satisfaction? In other words, how does the presence/absence of learner response affect learner satisfaction?

a) How do the different forms of kinetic energy (degree-based, closeness-based, and betweenness-based) change from mid-semester to the end of the semester?

b) How do the different forms of potential energy (degree-based, closeness-based, and betweenness-based) change from mid-semester to the end of the semester?

4) How does learner prior experience moderate/mediate the relationships of momentum, force and/or energy with learner satisfaction?

5) How does learner prior satisfaction moderate/mediate the relationships of momentum, force and/or energy with learner satisfaction?

In order to examine these five principal research questions, data from the following sources were needed: (1) discussion board text from online courses and (2) online learner satisfaction survey, which was given to learners in the online courses near the end of the sixteen-week semester.

Sample Description

A total of 102 students from a mid-western university volunteered from eleven courses to participate in the study during the 2005-06 academic year. Courses originated from the schools of information science, nursing and letters and science. Demographically, 88% of the respondents were female and 58% were full-time. Information on race (39% response rate) and age (53% response rate) is limited since the response rate to either optional item on the Learner Satisfaction Survey is low. Table A4-1 in the Appendix section reports the percentages (%) and counts (f) for these variables.

Learner Satisfaction: Descriptive Statistics

Prior to addressing the issue of learner satisfaction with the discussion boards, the learners were asked to answer questions about items that affected their ability to participate in the course (Sections II-A and II-B) and get coursework done (Section II-C) that they were currently in.

Items that Affected Learner's Ability to participate in the Course

Section II-A on the Learner Satisfaction Survey contained five questions rated on a seven-point Likert scale (1=strongly negative, 4=neutral, and 7=strongly positive) that addressed items that affected the learners ability to participate in the course. Table A4-2A in the appendix section reports the means, standard deviations (SD), ranges, skew and kurtosis coefficients for this section.

The range of these average values was between 5.2 and 5.7 out of 7.0 points, which indicated that each of them individually and collectively overall were rated slightly positive. The two highest rated items were: (a) personal success with online courses before this one (5.7), and (b) my ability to be responsible for my time (5.7). Furthermore,

the standard deviations are close to unit value (1.0) which indicates that most students rate these five items somewhere between neutral (4) and moderately positive (6) on the seven-point scale.

Peak symmetry was determined through the skew statistic and its corresponding standard error terms. Generally, if the absolute value of a ratio of skew/standard error < 2.0 indicates that the distribution curve is fundamentally symmetrical. Peak sharpness was determined through the kurtosis statistic and its corresponding standard error. Generally, if the absolute value of a ratio of kurtosis/standard error < 2.0 indicates that the distribution is mesokurtic. Most items have little or no skew and/or kurtosis, and are therefore symmetrical and mesokurtic.

Section II-B on the Learner Satisfaction Survey contained eight questions rated on a five-point Likert scale (1=none, 3=a small amount, and 5=a large amount). Table A4-2B in the Appendix section reports the descriptive statistics for this section.

The range of these average values was between 3.4 and 4.1 out of 5.0 points, which indicated that each of them individually and collectively overall affected the learner's ability to participate in the course by a small or moderate amount. In this section, the standard deviations are less than unit value (1.0) which isn't unusual since the range for the scale was smaller in Section II-B than it was in Section II-A. Most items have little or no skew and/or kurtosis, and are therefore symmetrical and mesokurtic.

Section II-C on the Learner Satisfaction Survey contained six questions rated on a seven-point Likert scale (1=interfered a lot, 4=had no effect, and 7=helped a lot). Table A4-2C in the Appendix section reports the means and standard deviations for this section.

The range of these average values was between 3.2 and 5.2 out of 7.0 points, which indicated that the items fell near the neutral mark (4.0) of the scale. However, the standard deviation is again near unit value. Therefore, most items on average in Section II-C interfered a little, helped a little, or had no effect. Most items have little or no skew and/or kurtosis, and are therefore symmetrical and mesokurtic.

Discussion Board Evaluation

Section III of the Learner Satisfaction Survey contained all of the items that constructed the outcome variable of this study: learner satisfaction. The 24 items were rated on a seven-point Likert scale (1=strongly disagree, 4=neutral, and 7=strongly agree) and grouped into nine categories to make it easier for learners to see the similarities in some of them. In addition there was an overall satisfaction item at the end of the survey for comparison to the average of all 24 items, and another item asking the learner if they would like to use discussion boards in the next course. Furthermore, all items in this section asked the learners to address each of the items as they applied mid-semester as well as at the end of the semester.

Results for Section III can be seen in Table A4-3 in the Appendix section. As can be seen from Table A4-3, the values are very similar between mid-semester and at the end of the semester. In addition, most of the individual items ranked above 4.0 (neutral) but never quite reached 5.0 (slightly agree). However, the standard deviations are all above unity and suggest that enough students rated these items between 3.0 (slightly disagree) and 6.0 (moderately agree) to make the variability between learners substantial for this part of the survey.

Note: Items 4a and 4b are "negatively" worded items. These items were placed in the survey in order to minimize effects of learners rating all 24 items with the same value. For all practical purposes this succeeded. However, ratings for items within each of the nine groups and between mid-semester and end of the semester were still quite similar. Negatively worded items were recoded later for inferential tests and reliability analysis.

Most items have minor, but insignificant levels of skew and kurtosis, and are therefore symmetrical and mesokurtic. Only a few items have a statistically significant negative kurtosis and therefore have slightly flatter curves (i.e., platykurtic) than would be expected of normal curves.

Learner Satisfaction: Inferential Statistics

Comparison of Mid-Semester to End of Semester Learner Satisfaction

Initial visual inspection of Table A4-3 reveals trends in some of the mean values of the overall and average learner satisfaction scores. Comparative analysis of the mid-semester and end of semester averages for the overall learner satisfaction item and the average of 24 learner satisfaction items are reported in Table 4-1.

Table 4-1

Comparison of Mid-Semester to End of Semester Learner Satisfaction

Item	Time	Mean (SD)	Mean Difference	t	df	p
Overall Learner Satisfaction	**Mid**	**4.07 (1.92)**	**0.07**	**1.829**	**98**	**.070**
	End	**4.14 (1.96)**				
Average of 24 Learner Satisfaction Items	**Mid**	**4.13 (1.30)**	**0.04**	**3.002**	**100**	**.003**
	End	**4.17 (1.30)**				

There is conflicting evidence between what is reported from the dependent t-tests of the overall satisfaction items and the average of the 24 satisfaction items. There is a

significant difference in the average of 24 learner satisfaction items between mid-semester and the end of semester ($t = 3.002$; $df = 100$; $p = 0.003$), but not for overall learner satisfaction ($t = 1.829$; $df = 98$; $p = 0.070$). This appears to be counter-intuitive since the mean difference is larger for the overall item (0.07) than the average item (0.04). Since the degrees of freedom (df) are nearly identical in each t-test, it is the smaller magnitude of the standard deviation of the average item that contributes to its statistically significant difference. Most likely, this arises from the fact that the overall learner satisfaction is determined from averaging whole numbers (1 - 7) as opposed to averaging means which have greater accuracy.

The end result is that the average values are more accurate than the overall values, which may explain why there is a statistically significant difference in learner satisfaction from mid-semester to the end of the semester. However, a difference of 0.04 on a seven-point scale is not practically significant, let alone very important. This information provides a check for data redundancy across time.

Mid-semester and end of semester values for both variables are highly correlated, and therefore highly redundant: (1) overall learner satisfaction ($r = 0.981$; $p < 0.001$) and (2) average of 24 learner satisfaction items ($r = 0.993$; $p < 0.001$). Normally for the purposes of prediction, a significant dependent t-test, coupled with a strong correlation ($r > 0.7$) would indicate the need for a univariate linear regression model. However, although the variables are highly correlated, the scales are the same for both variables in the model and the increase in overall and average values are small, it is easy to predict the value of one variable from the other and the regression model is itself redundant.

Comparison of Overall to Average Learner Satisfaction

Results for the comparison of the overall learner satisfaction item and the average of 24 learner satisfaction items for each of the two times (mid-semester and end of semester) in the semester are reported in Table 4-2.

Table 4-2

Comparison of Overall Learner Satisfaction to Average of 24 Learner Satisfaction Items

Time	Item	Mean (SD)	Mean Difference	t	df	p
Mid-Semester	**Over**	**4.04 (1.93)**	**0.08**	**0.832**	**99**	**.408**
	Ave	**4.12 (1.33)**				
End of Semester	**Over**	**4.14 (1.96)**	**0.06**	**0.590**	**98**	**.557**
	Ave	**4.20 (1.30)**				

In either situation, there is no significant difference between the overall and average values for either time during the semester. Furthermore, the overall and average values are highly correlated for both points of time: (1) mid-semester ($r = 0.882$; $p < 0.001$), and (2) end of semester ($r = 0.915$; $p < 0.001$). This indicates that an overall learner satisfaction rating is for all practical purposes reporting the same value as an average value of learner satisfaction at both times in the semester. This is useful for gauging learner attitudes from a single score and can help predict individual items which correlate highly with it (as discussed later). Since the variables are on identical scales, the ability to predict overall scores from average scores (and vice versa) is as simple as looking at the other score directly.

Reliability Analysis

Prior to examination of the 24 individual items on the Learner Satisfaction Survey, reliability analysis is needed to assess the internal consistency of the data for these items.

Aside from the demographic items on the survey, there are four major sections on the form. It was generally expected that the internal consistency of the 24 items in the last section (III) should be high (Cronbach alpha > 0.7) since the items were intentionally designed to be inter-related and measure the same general concept: learner satisfaction with online course discussion boards. Items in Sections II-A, II-B, and II-C are fewer in number for each section, and inter-relatedness was not as high as a priority as it was for Section III. The internal consistency results for each section are reported in Table 4-3.

Table 4-3

Reliability Analysis of Learner Satisfaction Survey (N_{MAX} = 102)

Section	Cronbach Alpha
II-A	**0.793**
II-B	**0.789**
II-C	**0.356**
III (Mid-Semester)	**0.971**
III (End of Semester)	**0.968**

Table 4-3 reveals that with the exception of data from Section II-C (items that affected learner's ability to get coursework done) data from all other sections have high internal consistency. However, unusually high internal consistency values can be problematic in that it indicates a reduction in certain aspects of variability. Most likely, learners are giving identical ratings (all good, all neutral, or all bad) for adjacent items on the form. While the survey was designed to take a short period of time to complete (20 minutes), it may still have been too long for some learners. The high internal consistency of Section III for either mid-semester (Cronbach alpha = 0.971) or end of semester (Cronbach alpha = 0.968) does not allow for the removal of any individual items, since there was little room for improvement. While this indicates strong reliability, it does not permit

shortening of the form. The internal consistency was high for section III for both mid-semester and end of semester, which again suggests redundancy in the data across the two time periods.

Factor Analysis

In order to determine the sub-structure of the Learner Satisfaction Survey, an exploratory factor analysis was used on the data. Specifically principal components extraction was coupled with Varimax rotation. This will maximize variance on the first component, yet minimize the number of variables that have high loadings on each factor, which simplifies interpretation of the factors (Kaiser, 1958).

Results for mid-semester and end of semester data are nearly identical. Therefore, only the results of the end of semester data are reported in Table 4-4. Four components were extracted from the data with thirteen items loading onto the first component and seven items loading onto the second component, with the remaining two components having two items each. The four components accounted for 84% of the total variance. Eigenvalues for the four components ranged from 1.104 to 14.110.

The distribution of items within the four components is not evenly split amongst them. This is not unusual for principal components extraction since the variance is maximized on the first component. However, the grouping of items from the factor analysis clearly illustrates conceptual relationships within each factor.

Table 4-4

Factor Analysis of 24 Learner Satisfaction Survey Items

#	Item	Component			
		1	2	3	4
7a	The length of my postings was **long enough.**	.883	.251	.107	.142
1a	There was **enough** time to respond to other people's messages on the discussion boards.	.866	.122	.020	.062
7c	The length of my peer's postings was **long enough.**	.861	.250	.160	.184
2a	I was able to post **enough** messages for each forum.	.849	.321	.098	.065
9b	Using the discussion boards was an **efficient** use of my time.	.847	.196	.134	.326
5a	The discussion board forums held my interest **adequately.**	.841	.308	.223	.120
2b	My peers were able to post **enough** messages for each forum.	.826	.341	.161	.026
9a	Using the discussion boards was a **good** use of my time.	.826	.214	.094	.339
6a	The pace of the discussions was **adequate** over the semester.	.806	.358	.071	.181
8c	The quality of my peer's postings was **good.**	.797	.217	.073	.392
1b	There was **enough** time to think of how to start a discussion on the discussion boards.	.786	-.006	.261	.053
2c	My instructor was able to post **enough** messages for each forum.	.784	.398	.063	.079
8a	The quality of my postings was **good.**	.774	.162	.124	.376
7d	The length of my peer's postings was **consistent.**	.143	.903	.092	.123
7b	The length of my postings was **consistent.**	.153	.900	-.037	.171
6b	The pace of the discussions was **consistent** over the semester.	.167	.895	-.039	.225
3c	My instructor posted messages **regularly.**	.261	.858	.103	.208
5b	The discussion board forums held my interest **consistently.**	.259	.850	.097	.030
3b	My peers posted messages **regularly.**	.377	.846	.156	.087
3a	I was able to post messages **regularly.**	.345	.816	.091	.151
4b	There were factors in my life that kept me from **consistently** (regularly) participating on the discussion boards.	.200	.045	.945	.061
4a	There were factors in my life that kept me from participating **enough** on the discussion boards.	.259	.154	.913	.143
8b	The quality of my postings was **consistent.**	.340	.290	.072	.813
8d	The quality of my peer's postings was **consistent.**	.392	.326	.202	.760

The two largest components are broken out into items related by amount (factor 1) and consistency (factor 2) of discussion board postings. Factor 3 items are related conceptually by forces in the student's life that kept them from participating on the discussion board postings. The two items in factor 4 are related by the quality and consistency of the discussion board postings. Factor 4 appears to be conceptually related to factor 2, but the factor analysis rules that out. Factor loadings are high (> 0.40) which indicate that the individual items within a factor correlate well with the factor.

Bartlett's Test of Sphericity was statistically significant (3429.177; df = 276; $p < 0.001$) and the Kaiser-Meyer-Olkin (KMO) Measure of sampling adequacy was 0.865. Bartlett's test of sphericity tests whether the correlation matrix is an identity matrix, which would indicate that the factor model is inappropriate. The KMO measure of sampling adequacy is an index for comparing the magnitudes of the observed correlation coefficients to the magnitudes of the partial correlation coefficients. Large values for the KMO measure indicate that a factor analysis of the variables is appropriate. Only 11% (26 of the 233) of the correlations in the correlation matrix fell below the cut-point of 0.30 for factor analysis, which indicates that the covariance amongst the items is adequate.

Table 4-5 reports that the internal consistency (i.e., inter-relatedness of items) via Cronbach alpha is high for the two largest factors as it was for the entire form. Since there are only two items in factors 3 and 4, a Pearson correlation coefficient was reported for them in Table 4-5 to illustrate the inter-relatedness of the two items in each factor. Both Pearson correlations are high ($r > 0.7$) and indicate a strong relationship within each

pair of items. Means and standard deviations are also reported for the factors to indicate average degree of satisfaction and spread of items within the factors respectively.

Table 4-5

Inter-Relatedness of Items in Four Factors of Learner Satisfaction Survey

Factor		# of Items	Cronbach	Pearson Correlation		Mean (SD)
#	Description	in Factor	Alpha	r	Sig.	
1	Amount	13	0.978	----------	----------	4.00 (1.64)
2	Consistency	7	0.963	----------	----------	4.56 (1.37)
3	Forces	2	----------	0.888	< 0.001	4.04 (1.63)
4	Quality and Consistency	2	----------	0.718	< 0.001	4.04 (1.23)
All		24	0.968	----------	----------	4.17 (1.30)

Initial examination of the factor mean values indicates that factor 2 (consistency) is considerably higher than the other three factors. Furthermore, factors 1 (amount), 3 (forces), and 4 (quality and consistency) are similar in mean values. Analyzing the six pair-wise differences required Bonferroni adjustment of six dependent t-tests, which are reported in Table 4-6A. Three of the six pair-wise factor comparisons were significantly different. As seen in Table 4-6B, all four factors are significantly, but moderately correlated (range of r is 0.260 to 0.649) to one another.

Table 4-6A

Comparison of Four Factors of Learner Satisfaction

Factor Pairs	Factor	Mean (SD)	Mean Difference	t	df	p
2 - 1	2	4.56 (1.33)	0.56	3.963	100	.001
	1	4.00 (1.64)				
2 - 3	2	4.56 (1.38)	0.52	2.778	97	.007
	3	4.04 (1.63)				
2 - 4	2	4.56 (1.37)	0.52	4.229	100	.001
	4	4.04 (1.23)				

Table 4-6B

Pearson Correlations of Four Factors of Learner Satisfaction

		Factor			
		1	2	3	4
Factor	1		.570	.403	.649
	2			.260	.561
	3				.353

In summary, the four factors are smaller separate facets of the overall construct of learner satisfaction for online discussion boards. This is illustrated by the moderate levels of strength of correlation between the six factor pairs, as well as the inter-relatedness of the items within each of the four factors. However, the number of items in each factor is not evenly distributed amongst them, indicating that the degree of items within the smaller constructs (#3 and 4), are not as well represented on the form as the larger constructs (#1 and 2). Of the four factors, the construct of consistency (factor #2) contributed to significantly higher levels of satisfaction then did all of the other three factors. No statistically significant differences were detected between the remaining three factor pairs (1-3, 1-4, 3-4).

Mid-Semester versus End of Semester Learner Satisfaction Scores

Since inferential statistics and reliability analysis suggests that there is relatively little difference between mid-semester and end of semester scores for learner satisfaction, the next few sections of this chapter will focus mostly on end of semester learner satisfaction scores.

Main Predictor Variables: Momentum, Force, and Energy

In order to construct the main predictor variables of momentum, force, and energy as indicated in chapter III, word counts and timestamps for discussion board postings were

extracted from online courses. Relationships between these variables as well as across time (mid-semester versus end of semester) will be determined in the next few sections. Later, the relationship between the main predictor variables and learner satisfaction will be examined to generate a core model. Finally, secondary predictor variables which moderate and mediate the relationship between the main predictor variables and learner satisfaction will be explored to generate a precision model.

Word Counts and Time-stamps: Descriptive and Inferential Statistics

Descriptive statistics (means, standard deviations, and sample sizes) of the mass (i.e., word counts) and time between messages from discussion board text help to characterize the asynchronous communication patterns seen in the online courses. Significant differences between the two times in the semester (not to be confused with the time between messages) are determined by dependent t-tests or a Wilcoxon signed ranks test, depending on the shape of the distribution.

Table's 4-7A and 4-7B reports the descriptive and inferential statistics of the mass, time between messages, and the ratio of mass and time for mid-semester and end of semester.

Note carefully that the mass/time ratio in Table 4-7B is an average of all individual mass/time ratios not a ratio of average mass to average time (which are both reported in Table 4-7A). This was calculated to keep the mass of each individual message directly connected to the time that passed between that message and the one it responded to. There are no statistically significant differences between mass, time, and the ratio of mass/time from mid-semester to end of semester.

Table 4-7A

Comparison of Mid-Semester to End of Semester Mass, Time between Messages and Mass/Time Ratios

Item	Time	Mean (SD)	Mean Difference	t	df	p
Mass (m) [# of words]	**Mid**	**151.0 (44.3)**	**5.0**	**1.768**	**51**	**.083**
	End	**146.0 (44.2)**				
Time (t) [hours]	**Mid**	**23.6 (16.7)**	**0.3**	**0.263**	**50**	**.794**
	End	**23.3 (15.0)**				

Table 4-7B

Comparison of Mid-Semester to End of Semester Mass/Time Ratios

Item	Time	Mean (SD)	Mean Difference	Wilcoxon	df	p
Mass / Time (m/t) [# of words/hour]	**Mid**	**55.4 (67.5)**	**-1.5**	**.347**	**50**	**.729**
	End	**56.9 (56.9)**				

Since the standard deviations are larger than the mean values for the mass/time ratio values, the mid-semester and end of semester distributions for this variable are skewed. Skew statistics for mid-semester (skew = 3.077; standard error = 0.333) and end-of-semester (skew = 2.771; standard error = 0.330) indicate that the ratios of skew/standard error > 2 which suggest that a non-parametric test would be more appropriate for this variable. A non-parametric Wilcoxon signed ranks test was used to determine any significant differences in the distributions of the mass/time scores and is reported in Table 4-7B.

Similarly, a non-parametric Spearman rho correlation is needed to determine the association of the mid-semester and end of semester mass/time scores. Mid-semester and end of semester values for all three variables are highly correlated, and therefore highly

redundant: (1) mass ($r = 0.893$; $p < 0.001$), (2) time ($r = 0.909$; $p < 0.001$), and mass/time (Spearman rho = 0.804; $p < 0.001$).

Momentum: Descriptive and Inferential Statistics

As reported in chapter III, the communication constructs of momentum, force, and energy depend not only on the variables of mass and time, but on distance as well. Distance values were determined via SNA. Three predominant distance values used in SNA were determined from the dataset: degree, closeness, and betweenness. The degree centrality is a measure of how many ties a learner has, which can be undirected or directed. Closeness centrality aggregates the geodesic distance from each learner to all others, where the geodesic distance is the number of relations in the shortest possible walk from one learner to another. Betweenness is measured by the proportion of all of the pathways connecting a learner to other learners.

Table's 4-8A and 4-8B report the descriptive and inferential statistics of degree, closeness and betweenness for mid-semester and end of semester. There is skew in the mean distance value based on betweenness and a non-parametric Wilcoxon signed ranks test is used to determine the significant differences in these scores and is reported in Table 4-8B. Similarly, a non-parametric Spearman rho correlation is needed to determine the association of the mid-semester and end of semester distance scores. Mid-semester and end of semester values for all three distance variables are highly correlated, and therefore highly redundant: (1) degree ($r = 0.960$; $p < 0.001$), (2) closeness ($r = 0.916$; $p < 0.001$), and betweenness (Spearman rho = 0.735; $p < 0.001$).

Table 4-8A

Comparison of Mid-Semester to End of Semester Distance (Degree and Closeness) Values from Social Network Analysis (SNA)

Item	Time	Mean (SD)	Mean Difference	t	df	p
Distance: Degree	**Mid**	**.048 (.032)**	**0.001**	**0.162**	**51**	**.872**
	End	**.047 (.027)**				
Distance: Closeness	**Mid**	**.644 (.176)**	**-0.085**	**-8.478**	**51**	**.001**
	End	**.729 (.145)**				

Table 4-8B

Comparison of Mid-Semester to End of Semester Distance (Betweenness) Values from Social Network Analysis (SNA)

Item	Time	Mean (SD)	Mean Difference	Wilcoxon	df	p
Distance: Betweenness	**Mid**	**3.04 (4.67)**	**1.04**	**3.074**	**51**	**.002**
	End	**2.00 (2.53)**				

The two distance values of closeness and betweenness produced statistically significant differences from mid-semester to end of semester, while the distance value of degree did not. Note that the scales are different for the three distance values.

Multiplying the variables of mass and distance, and dividing by time as explained in chapter III will produce the variable of momentum. Since the value of distance is taking three different forms, so too will the momentum. Table 4-9 reports the descriptive and inferential statistics of the three forms of momentum for mid-semester and end of semester. Since mass/time ratios required a non-parametric test to examine the differences in scores from mid-semester to end of semester scores then the momentum values will use the same non-parametric test since they are functionally dependent on

mass/time ratios. Again, skew is evident in the momentum distributions since the standard deviations are larger than the mean values, thus necessitating the use of non-parametric statistics.

Table 4-9

Comparison of Mid-Semester to End of Semester Momentum Values

Item	Time	Mean (SD)	Mean Difference	Wilcoxon	df	p
Momentum (Degree)	**Mid**	**3.41 (5.53)**	**-0.23**	**-.469**	**50**	**.639**
	End	**3.18 (4.23)**				
Momentum (Closeness)	**Mid**	**41.21 (57.42)**	**3.01**	**-.628**	**50**	**.530**
	End	**44.21 (49.75)**				
Momentum (Betweenness)	**Mid**	**166.4 (287.5)**	**-68.37**	**-2.109**	**50**	**.035**
	End	**98.0 (129.0)**				

Non-parametric Spearman rho correlations are needed to determine the association of the mid-semester and end of semester momentum scores. Mid-semester and end of semester values for all three momentum variables are highly correlated, and therefore highly redundant: (1) degree (Spearman rho = 0.840; $p < 0.001$), (2) closeness (Spearman rho = 0.826; $p < 0.001$), and betweenness (Spearman rho = 0.689; $p < 0.001$).

Table 4-9 indicates that there is a statistically significant difference in the momentum values based on betweenness from mid-semester to the end of semester, but not for the other two forms of momentum. In fact, the mean value for momentum based on betweenness decreases by 41.1%. Initially, this appears to be a data entry or typographical error. However, further examination of the means, standard deviations, frequency distributions, and individual scores reveals it is not.

Table 4-10 reports the frequency distribution for the mid-semester and end of semester momentum values based on betweenness, with the difference in the two values rounded

to units place and in descending order. Notice that the difference between the momentums observed at mid-semester compared to the end of semester values has a large range of values: -773 to +128. Note: Positive values of difference reflect an increase in momentum. What is obvious is that not only did more learners have less momentum (63%) by the end of the semester than those that had more momentum (37%), but the last six scores (#46 to 51) seem to show a marked decrease in momentum.

Table 4-10

Frequency Distribution for Mid-Semester to End of Semester Momentum (Betweenness) Values by Decreasing Differences (Forces)

#	Mid	End	Difference	#	Mid	End	Difference
1	5	134	128	**26**	26	19	-7
2	58	160	102	**27**	31	22	-9
3	2	83	81	**28**	23	11	-12
4	38	106	68	**29**	30	17	-14
5	63	119	56	**30**	74	51	-24
6	14	67	53	**31**	121	94	-27
7	67	101	34	**32**	113	86	-27
8	3	36	33	**33**	72	44	-29
9	54	81	27	**34**	70	40	-30
10	7	27	20	**35**	92	55	-37
11	9	29	20	**36**	94	56	-38
12	38	54	16	**37**	119	80	-39
13	0	14	13	**38**	140	98	-42
14	8	21	13	**39**	103	46	-57
15	1	13	12	**40**	151	66	-85
16	15	26	12	**41**	246	133	-113
17	93	105	11	**42**	340	209	-131
18	21	27	7	**43**	189	48	-140
19	84	88	5	**44**	245	89	-156
20	1	0	0	**45**	327	158	-169
21	6	5	0	**46**	330	15	-315
22	116	114	-1	**47**	532	202	-330
23	2	1	-2	**48**	759	383	-376
24	96	92	-4	**49**	1154	685	-469
25	16	12	-4	**50**	1311	573	-738
				51	981	208	-773

As stated in chapter III, differences in momentum are directly proportional to external forces. Therefore, the values for the difference in momentum reported in the fourth and last columns of Table 4-10 are a quantitative measure of external forces that will change a learner's momentum from mid-semester to end of semester.

Force: Descriptive Statistics

As described in chapter III, forces must be present to cause a change in momentum. Changes in learner momentum from mid-semester to end of semester are a result of forces across that time period. Larger forces are expected to produce larger changes in momentum. Experiencing forces over larger time periods are also expected to produce larger changes in momentum. The period of time in this study between measurements of momentum is eight weeks and does not change for any of the cases in the sample. Therefore the difference in the momentum values is standardized to that window of time and is a direct measurement of force, as seen in Table 4-10. The average force is: M (SD) = -68 (181). A mean value of -68 is moderate, but negative suggesting that overall momentum decreases slightly from mid-semester to end of semester.

Energy: Descriptive and Inferential Statistics

As stated in chapter III, energy is divided into two components: (1) kinetic energy (energy of motion), and (2) potential energy (stored energy). Table 4-11 reports the descriptive and inferential statistics of kinetic energy for mid-semester and end of semester. Not surprisingly, kinetic energy values reflect similar patterns as compared to the momentum values in Table 4-9. As with the values of momentum, kinetic energy values are on different scales due to the scales of the distance values (degree, closeness, and betweenness) which are used to construct them. Furthermore, only the kinetic energy

values based on betweenness show a significant decrease from mid-semester to end of semester, which parallels the trends in momentum in Table 4-9.

Non-parametric Spearman rho correlations are needed to determine the association of the mid-semester and end of semester kinetic energy scores. Mid-semester and end of semester values for all three kinetic energy variables are highly correlated, and therefore highly redundant: (1) degree (Spearman rho = 0.910; $p < 0.001$), (2) closeness (Spearman rho = 0.855; $p < 0.001$), and betweenness (Spearman rho = 0.748; $p < 0.001$).

Table 4-11

Comparison of Mid-Semester to End of Semester Kinetic Energy Values

Item	Time	Mean (SD)	Mean Difference	Wilcoxon	df	p
Kinetic Energy (Degree)	Mid	.00093 (.00138)	-.00020	-1.219	50	.223
	End	.00073 (.00092)				
Kinetic Energy (Closeness)	Mid	.158 (.193)	-.004	-.750	50	.453
	End	.154 (.179)				
Kinetic Energy (Betweenness)	Mid	7.508 (24.150)	-5.108	-3.290	50	.001
	End	2.400 (7.433)				

Table 4-12

Comparison of Mid-Semester to End of Semester Potential Energy Values

Item	Time	Mean (SD)	Mean Difference	Wilcoxon	df	p
Potential Energy	Mid	16.68 (4.63)	.10	-1.417	50	.156
	End	16.78 (4.70)				

Since potential (stored) energy was defined as a lack of activity on the discussion boards, it had to be estimated by the lack of messages posted. This was accomplished by identifying all initial messages in a thread and determining the number of students in the class that did not respond to the message. As Table 4-12 indicates, the potential energy

increased slightly, but not significantly between mid-semester and end of the semester. Mid-semester and end of semester values for potential energy is highly correlated, and therefore highly redundant: Spearman rho = 0.970; $p < 0.001$).

Relationship of Fundamental Variables and Learner Satisfaction

Correlations of the fundamental variables of mass, time, mass/time ratio and distance with learner satisfaction are reported in Tables 4-13A and 4-13B.

Table 4-13A

Spearman Correlations between Fundamental Variables of Mass, Time, Mass/Time, and Distance with Learner Satisfaction - Mid-Semester

Fundamental Variable		Learner Satisfaction			
		Overall (N=51)		Average (N=52)	
		rho	p	rho	p
Mass		-.144	.313	-.243	.083
Time		-.076	.600	-.063	.662
Mass/Time		.516	.001	.555	.001
Distance	Degree	.630	.001	.705	.001
	Closeness	.593	.001	.649	.030
	Betweenness	.212	.135	.302	.001

Table 4-13B

Spearman Correlations between Fundamental Variables of Mass, Time, Mass/Time, and Distance with Learner Satisfaction - End of Semester

Fundamental Variable		Learner Satisfaction			
		Overall (N=51)		Average (N=52)	
		rho	p	rho	p
Mass		-.058	.687	-.130	.360
Time		.020	.891	.012	.933
Mass/Time		.516	.001	.612	.001
Distance	Degree	.641	.001	.695	.001
	Closeness	.513	.001	.599	.001
	Betweenness	.129	.368	.174	.218

Mass and time do not significantly correlate with learner satisfaction at mid-semester or the end of the semester. Therefore, mass and time cannot be part of the core model as separate variables. The correlations between the ratio of mass/time and learner satisfaction at mid-semester or the end of the semester is moderately strong, and could be considered as part of the core model. Degree-based distance and closeness-based distance are also significantly correlated to learner satisfaction at mid-semester and at the end of the semester. These two distance values could also be considered as part of the core model. Relationships that have significant correlations improve slightly if average learner satisfaction is used instead of overall learner satisfaction. It will be determined in the next few sections if the combination of mass, time, and distance to produce the main predictor variables of momentum, force, and energy will produce improved correlations with learner satisfaction.

Relationship of Main Predictor Variables and Learner Satisfaction

The relationship of the main predictor variables to the outcome of learner satisfaction is critically important to supporting the model of this study. The association of each of the three main predictor variables to learner satisfaction will first be discussed individually and then collectively to generate the core model.

Momentum and Learner Satisfaction

Descriptive statistics for learner satisfaction and the three form of momentum (degree, closeness, and betweenness) are reported collectively in Table A4-4 in the Appendix section. Recall that learner satisfaction was on a seven-point Likert scale (1=strongly disagree, 4=neutral, and 7=strongly agree). Note: The three different types of momentum

are on different scales. Consequently, comparisons in Table A4-4 should be limited to differences in mid-semester and end of semester scores.

Spearman rho correlations between learner momentum and learner satisfaction are reported in Tables 4-14A and 4-14B for mid-semester and end of semester data. All correlation values are statistically significant and range from 0.477 (moderately strong) to 0.801 (strong). Two patterns emerge from Tables 4-14A and 4-14B: (1) correlations of any form of learner momentum with average learner satisfaction values are always higher than with overall learner satisfaction values, and (2) correlations of either form of learner satisfaction with learner momentum decreases in magnitude from degree-based momentum to closeness-based momentum to betweenness-based momentum.

Table 4-14A

Spearman Correlations between Momentum and Learner Satisfaction - Mid-Semester

		Learner Satisfaction			
		Overall (N=50)		Average (N=51)	
		rho	p	rho	p
Learner Momentum	Degree	.651	.001	.692	.001
	Closeness	.575	.001	.623	.001
	Betweenness	.540	.001	.599	.001

Table 4-14B

Spearman Correlations between Momentum and Learner Satisfaction - End of Semester

		Learner Satisfaction			
		Overall (N=50)		Average (N=51)	
		rho	p	rho	p
Learner Momentum	Degree	.719	.001	.801	.001
	Closeness	.605	.001	.700	.001
	Betweenness	.477	.001	.565	.001

Comparison of correlation values in Tables 4-14A and 4-14B to Tables 4-13A and 4-13B respectively indicates an increase in correlation strength of 0.1 to 0.3 when correlating momentum to learner satisfaction instead of correlating any of the distance variables to learner satisfaction.

Force and Learner Satisfaction

Recall from chapter III that force is directly proportional to the difference in two values of momentum. The correlation of the difference in momentum scores (i.e., force) from mid-semester to end of semester (such as those that were reported in Table 4-10) with learner satisfaction scores are reported in Table 4-15. Four of six correlations are statistically significant ($p < 0.05$), but are not very important as the values are so low. Note that all correlations are negative which indicates that as force values become more negative (i.e., end of semester momentum is lower than mid-semester), learner satisfaction becomes more positive.

Table 4-15

Spearman Correlations between Force and Learner Satisfaction

		Learner Satisfaction			
		Overall (N=50)		Average (N=51)	
		rho	p	rho	p
Force	Degree	-.380	.007	-.335	.016
	Closeness	-.190	.187	-.189	.184
	Betweenness	-.366	.009	-.354	.011

Energy and Learner Satisfaction

The correlation of the kinetic energy and potential energy scores with learner satisfaction scores are reported in Tables 4-16A and 4-16B. Note that kinetic energy scores based on the distance values of degree correlate positively with learner

satisfaction, and are moderate in strength. Remaining correlations where kinetic energy values depend on the distance values of closeness or betweenness are either very low or not statistically significant. Potential energy scores correlate negatively with learner satisfaction and are also moderate in strength.

Table 4-16A

Spearman Correlations between Kinetic/Potential Energy and Learner Satisfaction - Mid-Semester

		Learner Satisfaction			
		Overall (N=50)		Average (N=51)	
		Rho	p	Rho	p
Learner Kinetic Energy	Degree	.506	.001	.498	.001
	Closeness	.313	.027	.290	.039
	Betweenness	.178	.217	.213	.133
Learner Potential Energy		-.465	.001	-.462	.001

Table 4-16B

Spearman Correlations between Kinetic/Potential Energy and Learner Satisfaction - End of Semester

		Learner Satisfaction			
		Overall (N=51)		Average (N=52)	
		Rho	p	Rho	p
Learner Kinetic Energy	Degree	.447	.001	.472	.001
	Closeness	.205	.149	.228	.103
	Betweenness	.055	.701	.097	.493
Learner Potential Energy		-.428	.002	-.478	.001

Core Model of Learner Satisfaction: Summary of Spearman Correlations

The structural core model of this study based on Spearman correlations is presented in Figure 4-1. All correlations present in the diagram are statistically significant ($p < 0.05$).

Although statistically significant correlations between the main predictor variables were expected, multicollinearity produces the undesirable consequence of reduced statistical power for a linear regression model. Consequently, the regression model in Table 17 does not include all of the main predictor variables due to a decrease in statistical power. However, as will be reported later, additional mediator and moderator variables will improve the precision of the core model (which only contains the main predictor variables and the outcome variable of learner satisfaction).

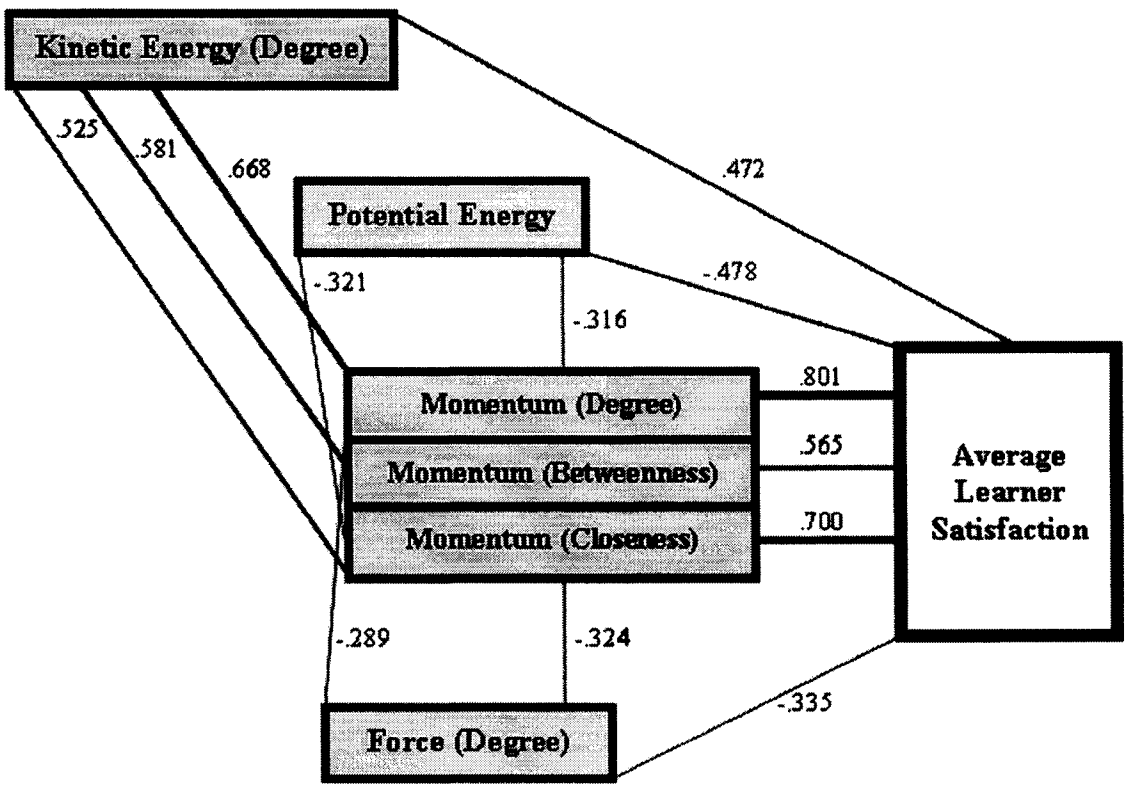


Figure 4.1: Core model consisting of statistically significant Spearman correlations ($p < 0.05$) of main predictor variables and outcome variable of learner satisfaction.

Core Model of Learner Satisfaction: Linear Regression

The linear regression model of learner satisfaction onto the main predictor variables is presented in Table 4-17.

Table 4-17

Linear Regression Model of Learner Satisfaction on Main Predictor Variables

Model		Beta	t	p	tolerance	VIF
A	**Momentum (Degree)**	**.498**	**3.952**	**.001**	**.651**	**1.535**
	Potential Energy	**-.334**	**-3.060**	**.004**	**.869**	**1.151**
	Kinetic Energy (Degree)	**.188**	**1.724**	**.091**	**.869**	**1.151**
	Force (Degree)	**.068**	**0.595**	**.555**	**.791**	**1.264**
Overall Significance of Model: $F(4,46) = 12.677$; $p = 0.001$						
Overall Goodness of Fit of Model: $R^2 = 0.524$						

Secondary Predictor Variables: Moderators and Mediators

In order to improve the precision of the core model of learner satisfaction, additional variables were measured with regards to learner prior experience and learner prior satisfaction. The next few sections will report the relationship of these two variables with respect to the structural core of the learner satisfaction model. Analysis of these items as moderator, mediator, or separate predictor variables will improve the precision of the core model.

Ideally, the learner satisfaction model should have strong predictor variables that are not correlated significantly with each other. Correlation amongst predictor variables in a regression model is called multicollinearity, which decreases statistical power and weakens the analysis of the model. However, there may be additional variables that are related to the model which moderate or mediate the effects within it. The presence and

effect of these moderator and/or mediator variables can be revealed through correlation and regression analysis (Baron & Kenny, 1986).

Learner Prior Experience

Learner prior experience is significantly correlated with three types of learner momentum, two types of kinetic energy, and learner satisfaction as seen as shaded items in Table 4-18A. If learner prior experience were to be considered a separate predictor variable, significant correlations between it and any of the main predictor variables are problematic because it raises the issue of multicollinearity in regression. In the context of this study, learner prior experience is not considered as a main predictor variable, and subsequent analyses are designed to examine its effects as a moderator variable for any of the main predictor variables.

Table 4-18A

Spearman Correlations with Learner Prior Experience (N=41)

Item		Rho	p
Momentum	**Degree**	**.622**	**.001**
	Closeness	**.489**	**.001**
	Betweenness	**.608**	**.001**
Force	**Degree**	**-.125**	**.444**
	Closeness	**-.074**	**.650**
	Betweenness	**-.307**	**.054**
Kinetic Energy	**Degree**	**.538**	**.001**
	Closeness	**.296**	**.061**
	Betweenness	**.363**	**.020**
Potential Energy		**-.135**	**.399**
Learner Satisfaction		**.499**	**.001**

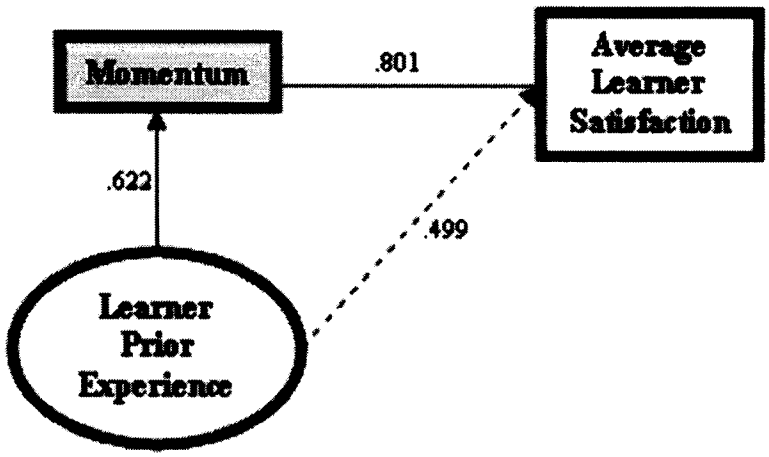


Figure 4-2: Model of learner prior experience acting as a moderator for momentum (predictor) and average learner satisfaction (outcome).

As illustrated in Table 4-18A, learner prior experience has significantly correlated with many predictor variables and the outcome variable. Figure 4-2 is a visual depiction of the relationships between the variables momentum (degree), learner satisfaction, and learner prior experience. Ideally, there should be a strong relationship between momentum and learner satisfaction, which is seen through the high value of the correlation coefficient (rho = 0.801). There is a moderately strong relationship between learner prior experience and momentum, which in this case is rho = 0.622. Furthermore, there is a moderately strong relationship between learner prior experience and learner satisfaction (rho = 0.499) and is illustrated by the dashed line in Figure 4-2.

Examination of learner prior experience as a moderator variable would lead to expectations of relationships between it and the main predictor variables, but not with the outcome variable of learner satisfaction.

Regression analysis can be used to statistically support the moderating effects of learner prior experience on any of the main predictor variables. Ideally, a regression

analysis in this context will report statistically significant contributions from the independent variable and the interaction of the independent variable with the moderator variable, but not with the moderator variable.

Using learner prior experience as the suspected moderator variable provides only one (out of a possible 10) significant linear regression model, which is reported in Table 4-18B. Examination of the only significant regression model obtained under these conditions indicates a highly significant model ($F(3,37) = 5.249$; $p = 0.004$) with a goodness of fit index of $R^2 = 0.299$. The moderator variable, predictor variable (kinetic energy (betweenness)) and their interaction are all significant contributors to the regression model. This suggests that learner prior experience is acting as a separate predictor variable as well as a moderator variable for kinetic energy.

The lack of a significant regression model (for the nine remaining predictor variables) does not negate the relationships between learner prior experience and other predictor variables such as momentum as they were already established through correlations. However, it does weaken the evidence of it acting as a moderator variable when the outcome variable is learner satisfaction in a linear regression.

Table 4-18B

Regression Analysis of Learner Satisfaction on Main Predictor Variables

Moderator Variable: Learner Prior Experience

Model	Item	Beta	t	p
A	**Kinetic Energy (Betweenness)**	**0.558**	**3.672**	**.001**
	Learner Prior Experience	**1.981**	**2.221**	**.033**
	Interaction	**-1.910**	**-2.115**	**.041**
Overall Significance of Model: $F(3, 37) = 5.249$; $p = 0.004$				
Overall Goodness of Fit of Model: $R^2 = 0.299$				

Learner Prior Satisfaction

Learner prior satisfaction will yield a significant correlation with three types of learner momentum and two types of kinetic energy as seen as shaded items in Table 4-19A.

Table 4-19A

Spearman Rho Correlations with Learner Prior Satisfaction (N=52)

Item		Rho	p
Momentum	**Degree**	**.347**	**.012**
	Closeness	**.289**	**.038**
	Betweenness	**.407**	**.003**
Force	**Degree**	**.012**	**.932**
	Closeness	**.026**	**.855**
	Betweenness	**.047**	**.743**
Kinetic Energy	**Degree**	**.284**	**.042**
	Closeness	**.182**	**.195**
	Betweenness	**.301**	**.030**
Potential Energy		**-.044**	**.756**
Learner Satisfaction		**.164**	**.246**

Table 4-19B

Regression Analysis of Learner Satisfaction on Main Predictor Variables

Moderator Variable: Learner Prior Satisfaction

Model	Item	Beta	t	p
A	**Potential Energy**	**-.539**	**-3.779**	**.001**
	Learner Prior Satisfaction	**.048**	**0.339**	**.736**
	Interaction	**.332**	**2.306**	**.027**
Overall Significance of Model: $F(3,37) = 5.945$; $p = 0.002$				
Overall Goodness of Fit of Model: $R^2 = 0.325$				

Table 4-19B reports the results of the linear regression analysis of learner satisfaction on learner prior satisfaction the main predictor variables and the interaction variables yielded only one model with a significant interaction term. However, the regression model meets all conditions for containing a moderator variable: predictor variable and

interaction are significant contributors and the moderator variable is not a significant contributor.

Precision Model of Learner Satisfaction: Summary of Correlations

The precision model of this study based on Spearman correlations is presented in Figure 4-3. The main predictor variables are shaded rectangles, the outcome variable is a non-shaded rectangle, and the moderator/mediator variables are non-shaded ellipses. Due to spatial limitations it was not possible to place all of the numerical values of the correlations on the diagram.

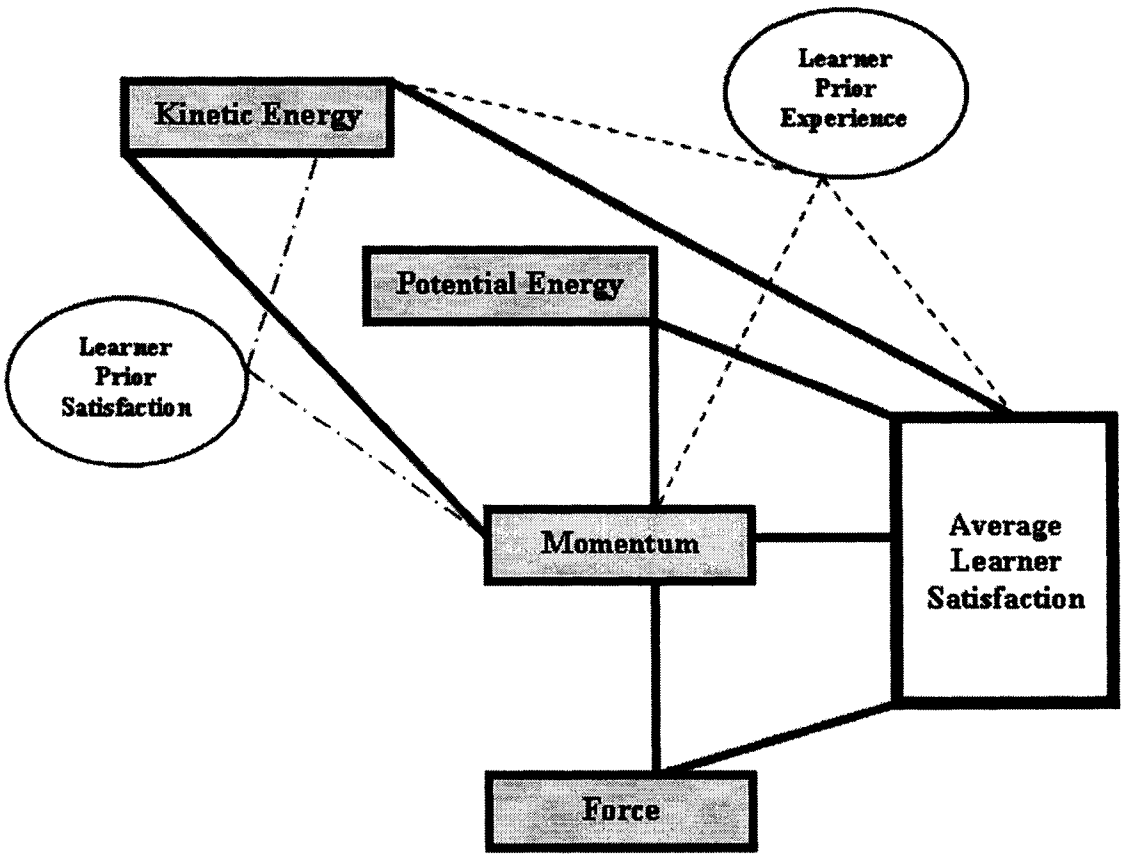


Figure 4.3: Precision model consisting of statistically significant Spearman correlations ($p < 0.05$) of moderator/mediator variables (ellipses), main predictor variables (shaded rectangles) and outcome variable of learner satisfaction (non-shaded rectangle).

All correlations present in Figure 4-3 are statistically significant ($p < 0.05$) and are summarized in Table 4-20. All five secondary variables in the precision model act as moderators for at least one of the main predictor variables which were confirmed by linear regression modeling.

Table 4-20

Precision Model Summary of Statistically Significant Correlations

#	Variable 1 Main Predictor Variable	Variable 2 Outcome Variable	Rho	p
1	Momentum	Average Learner Satisfaction	.801	.001
2	Kinetic Energy	Average Learner Satisfaction	.472	.001
3	Potential Energy	Average Learner Satisfaction	-.478	.001
4	Force	Average Learner Satisfaction	-.335	.016
#	Main Predictor Variable	Main Predictor Variable	Rho	p
5	Momentum	Kinetic Energy	.668	.001
6	Momentum	Potential Energy	-.316	.022
7	Momentum	Force	-.324	.021
#	Main Predictor Variable	Secondary Variable	Rho	p
8	Momentum	Learner Prior Experience	.622	.001
9	Kinetic Energy	Learner Prior Experience	.538	.001
10	Momentum	Learner Prior Satisfaction	.407	.003
11	Kinetic Energy	Learner Prior Satisfaction	.301	.030
#	Secondary Variable	Outcome Variable	Rho	p
12	Learner Prior Experience	Average Learner Satisfaction	.499	.001

Summary of Results

This study's results demonstrate an empirical relationship of online discussion board interactions of adult learners and their satisfaction with their experience. Specifically, this was established through the statistical association of the asynchronous volumetric and frequency communication patterns through online discussion boards and adult learner

satisfaction for 102 adult learners at a mid-western university during the 2005-2006 academic year. The communication constructs of momentum, force, and energy acted as predictor variables in this investigation and were significantly related to the outcome of learner satisfaction and constituted the structural core of this study's model as determined by correlations and linear regression modeling. A highly reliable (alpha = 0.97) and valid learner satisfaction form was ascertained through internal consistency calculations and exploratory factor analysis for the outcome variable.

The first three (of five) principal research questions that this study addressed and the results obtained are listed in Table 4-21.

Table 4-21

Summary of Findings for the First Three Principal Research Questions

#	Research Question	Results	
		Rho	p
1	How does the **momentum** of communication patterns in an online discussion board affect the outcome of learner satisfaction?	**.801**	**.001**
2	How do external **forces**, which change the momentum of communication patterns in an online discussion board, affect the outcome of learner satisfaction?	**-.335**	**.016**
3	How does the amount of **kinetic energy** of communication patterns in an online discussion board affect the outcome of learner satisfaction?	**.472**	**.001**
	How does the amount of **potential energy** of communication patterns in an online discussion board affect the outcome of learner satisfaction?	**-.478**	**.001**

From the results in Table 4-21 it can be seen that the individual relationships between each of the predictor variables and the outcome variable of learner satisfaction are statistically significant. The relationship between momentum and learner satisfaction is very strong, the relationships between the two forms of energy (kinetic and energy) are

moderately strong, and the relationship between force and learner satisfaction is present, albeit weak. The linear regression analysis of learner satisfaction onto the main predictor variables as reported in Table 4-17 reports that only momentum and potential energy are significant contributors to the model.

The results for the five sub-questions of the first principal research question are listed below in Table 4-22.

Table 4-22

Five Sub-Questions of the First Principal Research Question

#	Research Sub-Question	Results
1a	How does the learner satisfaction change from mid-semester to the end of the semester?	No statistically significant change ($p = 0.070$).
1b	How do the individual learner satisfaction items group into larger learner satisfaction factors?	Four factors produced from exploratory factor analysis.
1c	How does the amount of text posted and the rate of response change from mid-semester to the end of the semester?	No statistically significant change for the amount of text ($p = 0.083$) or the rate of response ($p = 0.794$).
1d	How do the different forms of distance (degree, closeness, and betweenness) between learners change from mid-semester to the end of the semester?	No statistically significant change for degree-based distance ($p = 0.872$). Statistically significant increase for closeness-based distance ($p = 0.001$) and decrease for betweenness-based distance ($p = 0.002$).
1e	How do the different forms of momentum (degree-based, closeness-based, and betweenness-based) change from mid-semester to the end of the semester?	No statistically significant change for degree-based momentum ($p = 0.639$) or closeness-based momentum ($p = 0.530$). Statistically significant decrease for betweenness-based momentum ($p = 0.035$).

The two secondary variables were correlated to the main predictor variables and/or the outcome variable which increased the precision of the correlation model as seen in Table 4-20. However, correlations to predictor variables may cause multicollinearity in the

linear regression models when testing for moderator variables. Learner prior experience and learner prior satisfaction were confirmed to act as moderator variables through linear regression models as reported in Table 4-23. Neither learner prior experience nor learner prior satisfaction was confirmed to act as a mediator variable for any of the three main predictor variables (momentum, force, or energy) and the outcome variable of learner satisfaction.

Table 4-23

Summary of Findings for Secondary Variables to act as Moderator Variables

#	Secondary Variable	Main Predictor Variable	Secondary Variable Acts as Moderator	Secondary Variable Acts as Mediator
1	**Learner Prior Experience**	**Kinetic Energy**	**yes**	**no**
2	**Learner Prior Satisfaction**	**Potential Energy**	**yes**	**no**

Adding the secondary variables to the main predictor variables and the outcome variable of learner satisfaction created a more complete model to address the last two (of five) research questions of this study.

In conclusion, all main predictor variables are significantly related to learner satisfaction and constitute the structural core of the model. Secondary variables moderated the effects of the main predictor variables onto learner satisfaction and helped generate a more precise model.

CHAPTER V

Discussion, Implications for Teaching and Learning, and Future Research

Introduction

The purpose of this study was to investigate the relationship of online discussion board interactions of adult learners and their satisfaction with their experience. Specifically, this study's objectives were to examine the asynchronous volumetric and frequency communication patterns through online discussion boards and the association to adult learner satisfaction. The communication patterns were measured from constructs of physical parameters used in the natural sciences, and the outcome variable was measured from multiple items of an online learner satisfaction survey as they related to communication patterns.

This study had five principal research questions, which in some cases were divided into numerous sub-questions and stated in chapters I, III, and IV. The results generated from the data are discussed in this chapter in the order of the research questions presented in the previous three chapters. Since all five principal research questions focused on the outcome of learner satisfaction, that is where the discussion will start. The first section of this chapter examines the psychometric qualities of the outcome variable learner satisfaction. It will also discuss any differences in learner satisfaction between mid-semester and the end of the semester. The next section analyzes the main predictor variables of momentum, force, and energy which constitutes the communication constructs for the core model of this study, their relationship to each other and to learner satisfaction. The third section studies the addition of two moderator variables to the core

model to create a more comprehensive precision model. The section after that is on implications for teaching and learning, and the final section is on future research.

Learner Satisfaction: Psychometric Qualities

Learner Satisfaction: Reliability

Earlier studies by Gray and Laidlaw (2004), Wang (2003), Elliott and Shin (2002) and Downs and Hazen (1977) indicated that learner satisfaction as an outcome was a multi-item construct which could be grouped into factors to produce a form that could collect reliable data. It was necessary to conduct this study in response to Wang (2003) who indicated that learner satisfaction in asynchronous electronic systems had not yet been developed into a factorable, reliable, and valid multi-component item.

Learner satisfaction data collected for this study had strong internal consistency and was well-factored. The internal consistency of the individual learner satisfaction items was examined through a reliability coefficient called Cronbach alpha, designed to measure the inter-relatedness of related items (Cronbach, 1951). The internal consistency of the learner satisfaction data for this study was high for retrospective mid-semester and end of semester evaluation (Cronbach alpha = 0.97 in both cases). This high level of reliability for a learner satisfaction form was not unprecedented as was recently reported by Wang (2003) whose e-Learner Satisfaction form had an internal consistency of alpha = 0.93 and Elliot and Shin (2002) whose Student Satisfaction Inventory form had an internal consistency of alpha = 0.97. Generally, high values of inter-relatedness (reliability > 0.7, correlation > 0.7, agreement > 0.6) are desired (Feldt, Woodruff, & Salih, 1987; Landis & Koch, 1977; Cronbach, 1951) in data sets in order to provide consistent and replicable results from the instruments used. However, extremely high

values of inter-relatedness (reliability > 0.9, correlation > 0.9, agreement > 0.8) can be problematic for reasons such as redundancy and low variability (Maxwell, Camp, & Arvey, 1981).

In order to interpret the reliability via internal consistency, additional information regarding the uni-dimensionality of the scale beyond Cronbach alpha was required (Shevlin, Miles, Davies, & Walker, 2000; Boyle, 1991). Inter-item correlation matrices are useful indicators of the underlying relationships between individual items, and whether they are measuring along the same dimension of learner satisfaction. While the high values of alpha obtained for the form specified a high degree of item inter-relatedness, it did not by itself indicate a uni-dimensional measurement of learner satisfaction (Gardner, 1995). Uni-dimensionality was established through assessment of the 24 x 24 inter-item correlation matrix (not shown in chapter IV due to spatial limitations), where no pair-wise correlation was lower than the statistical significance cut-point of r = 0.30 (Gardner, 1995). The combination of a high value of Cronbach alpha and having no correlation in the matrix lower than r = 0.30 indicated that the data from the survey form had strong internal consistency and was uni-dimensional with respect to learner satisfaction.

High values of internal consistency do not easily permit multiple-item surveys to be modified through item-deletion due to ceiling effects, and there is little statistical support for such deletions on the learner satisfaction form. Furthermore, high values of internal consistency indicated that many learners were reporting very similar scores for all learner satisfaction items. This will increase internal consistency, but decrease variability and the ability to differentiate between items, particularly with small scales. Increasing the

variability and reliability was accomplished through the use of a clearly labeled, seven-point scale for all learner satisfaction items (Weng, 2004). Furthermore, items on the learner satisfaction form were grouped by ordering and shading of the table cells so as to create a visual break in learner ratings of satisfaction and generate more variability in the data.

Learner Satisfaction: Factor Analysis

In addition to the high internal consistency and uni-dimensionality of the data collected for the form, exploratory factor analysis revealed that the data were clearly sub-structured into four distinguishable factors. Principal components extraction was coupled with Varimax rotation in order to maximize variance on the first component yet minimize the number of variables that have high loadings on each factor, which was to simplify interpretation of the factors (Kaiser, 1958). While factor analysis can lead to quantifiably discernable factors, interpretation is sometimes vague (Sitek, Gullberg, & Huesman, 2002). Factors can be unstable, unless sample sizes are high ($N > 100$ and $N > 10$*(number of items)) or communalities are strong ($h > 0.6$). High communalities can offset small sample sizes (Hogarty, Hines, Kromrey, Ferron, & Mumford, 2005). The sample size was small for a factor analysis of 24 learner satisfaction items in this study, but the communalities were larger than 0.8. Factor stability would be at an acceptable level if the sample size was at least $N = 240$ for the 24-item survey (Rummel, 1970), but that was unrealistic due to the limited resources of this study. Online courses usually contain ten to fifteen learners, and return rates on surveys typically range from 40 to 80 percent (Szirony, Telljohann, Price, & Wolfe, 2002).

In the context of this study, the four factors were easily separated because of the high loadings of the items onto the factors, but interpretation was ambiguous due to the fact that factor #4 (quality/consistency) had some conceptual similarities with factor #2 (consistency). The four factors were also inter-related established by the statistically significant correlations between them (range of r is 0.260 to 0.649). This range is typical for factor analysis of well-structured satisfaction outcomes (Thurmond, 2003). It indicated that the factors were well-balanced between their own conceptual distinctiveness and yet measured the same overall outcome of learner satisfaction (Downs & Hazen, 1977; Gray & Laidlaw, 2004).

The rotated component matrix from exploratory factor analysis (Doll, Raghunathan, Lim, & Gupta, 1995) and the inter-item correlation matrix from reliability analysis were used to determine convergent and divergent validity (Campbell & Fiske, 1959) of the learner satisfaction data. The inter-item correlation matrix revealed that items within a single factor were no lower than $r = 0.5$, indicating good convergent validity for those items. Divergent validity was determined by ensuring that the number of times that individual items of a given factor correlates higher with items of the same factor than with items of a different factor at least fifty percent of the time. High factor loadings for the four factors, strong convergent validity of items within factors, and robust divergent validity between factors indicated that the data from the learner satisfaction survey is well-factored.

The number of items was asymmetrically distributed within the four factors, which made it difficult for each factor to have equal representation on the form (Hinkelmann & Kempthorne, 2005). The four factors are best described by the conceptual similarity and

cohesion of the items within each one, and are described as follows: Factor 1 - amount of communication, factor 2 - consistency of communication, factor 3 - external forces affecting communication, and factor 4 - quality/consistency of communication.

Factors 1 and 2 had the majority (20 of 24) of items of learner satisfaction. The conceptual relationship of these two factors from the outcome variable to the main predictor variables can be described as follows. Factor 1 is conceptually related to the main predictor variables of momentum and energy since each is directly related to the amount of communication on the discussion boards. Factor 2 is inversely related to the main predictor variable of force, an indicator of the consistency of communication. Since force is directly proportional to any measured change in momentum from mid-semester to end of semester, high values of consistency would imply low changes in momentum, and therefore low values of force. Factors 3 and 4 each had only two items, and both factors of which were conceptually related to force. Overall, these interpretations correspond well to the underlying meaning of the main predictor variables in this study which are described in chapter III.

Collectively, reliability analysis, inter-item correlations, and factor analysis reported that the learner satisfaction survey had inter-related items that generally measured the strong internal consistency and uni-dimensionality of learner satisfaction, and was sub-structured into four different factors. This provides a learner satisfaction form that met the challenges set forth recently by Wang (2003).

Comparison of Mid-Semester to End of Semester Learner Satisfaction

Comparative analysis of mid-semester to end of semester learner satisfaction scores indicated if learner attitudes are stable over time. The results in chapter IV indicated that

mean values of learner satisfaction changed very little over time as seen through insignificant t-tests. This indicated that the sample as a whole did not change very much. However, in order to establish stable values across time for individuals, it was necessary to examine the correlation between the two scores. A strong correlation between mid-semester and end of semester scores indicated that individual learner's attitudes were also relatively unchanged.

Limited resources and a need to maximize statistical power required the use of retrospective mid-semester measurements (Hill & Betz, 2005; Gutek, 1978). While the learner satisfaction scores for mid-semester are measured retrospectively, it is suggested that learner satisfaction that is measured mid-semester can predict what will be measured at the end of the semester, given that they are strongly associated with each other. Note: In most circumstances it would be necessary to use linear regression modeling for prediction. However, since the relationship under examination is strong ($r > 0.9$ for both overall and average learner satisfaction scores), consists of only two variables and both are measured with the same scale, a linear regression becomes redundant. Prediction of one variable is as easy as visually inspecting the other variable.

Comparison of Overall and Average Learner Satisfaction

Normally, single-item measurements for broadly defined constructs such as learner satisfaction are not preferred since they are unlikely to adequately measure its multiple facets. Furthermore, conceptual or measurement errors will invalidate single-item measurements. Multiple-item surveys limit the adverse effect of a single invalid item to a comparatively small reduction in validity (Straus & Baron 1990). Correlations between variables improve if multiple items are used to determine an average value for each

variable, rather than a single overall item (Carmines & Zeller, 1991). However, single-item measurements require fewer resources than multiple-item measurements, and are more easily obtained. If a strong relationship exists between an overall single-item variable and the average of multiple items of that same variable, then a single item variable is a useful measurement for rapid assessment. Correlations between overall and average learner satisfaction were high ($r > 0.8$) at both mid-semester and at the end of semester, which indicated that the overall measure could be quickly and accurately used as a measure and gauge for learner satisfaction. This is particularly helpful when researchers must account for student survey fatigue at the end of the semester (Porter, Whitcomb, & Weitzer, 2004). Similar positive relationships were reported recently by Roszkowski and Ricci (2005) in their examination of single-item and multiple items (N=25) of learner satisfaction, although their relationships were slightly lower in strength.

Main Predictor Variables: Momentum, Force, and Energy

Main Predictor Variables and the Core Model

The communication constructs of momentum, force, and energy were functionally and theoretically modeled after the physical parameters of momentum, force, and energy in order to create a conceptual relationship between these parameters from the natural sciences to the social sciences (Tonfoni, 1996). The mathematical and conceptual relationships that exist between momentum, force, and energy in the natural sciences have been extrapolated to the social sciences (Dinges, 2001; Plaud & Gaither, 1996; Harpole, 1996). While the disciplinary gap that exists between the natural and social sciences has made interdisciplinary research of this magnitude rare (Wright, 2006), it

should not invalidate the model. Küppers and Lenhard (2005) have stated that the natural sciences are structurally equivalent to the social sciences and that assessment of validity in the natural sciences can extend to the social sciences.

While examination and measurement of human behavior can have more variability than the motion or energy of inanimate objects, the structural core of some human behavior can be described with physical parameters. Therefore, this study created two models that described the relationship of learner behavior using physical parameters to learner attitude: (a) structural core model, and (2) high precision model. The structural core model emulated the kinetic and thermodynamic relationship of the three main parameters under investigation: momentum, force, and energy. The high precision model included those parameters and additional variables to account for human behavior that wasn't fully explained by physical parameters.

It was determined that the communication constructs of momentum, force, and energy were the main predictor variables in the core model of learner satisfaction, and not the fundamental variables of mass, time, and distance that they were created from. The correlations of the fundamental variables of mass or time with average learner satisfaction were low ($r < 0.10$) and therefore ruled out as predictor variables in the core model. Two of the three distance values were significantly correlated with learner satisfaction, but were not as high as the correlations between momentum and learner satisfaction or energy and learner satisfaction. The amalgamation of mass, time, and distance values to produce the main predictor variables of momentum and energy was necessary to demonstrate that in combination they correlated more strongly with average learner satisfaction than they did individually. Therefore, the main predictor variables of

momentum and energy are at the structural core of this study's model, not the three fundamental variables (mass, time, and distance).

In order to investigate the idea that the main predictor variable of force instead of mass, time, or distance should be at the structural core of the model, statistical changes in these variables from mid-semester to the end of the semester were examined. It was determined that no statistically significant differences existed for mass, time, or the ratio of mass/time from mid-semester to the end of the semester. Therefore, significant changes in momentum (i.e., force) across the semester were potentially left to occur only through the fundamental variable of distance.

Aggregate values of degree-based distance and closeness-based distance were not significantly different from mid-semester to the end of semester. Significant changes in distance from mid-semester to the end of the semester only occurred for the betweenness-based distance values. Likewise, significant changes in betweenness-based momentum were also demonstrated. However, while the association of changes in betweenness-based momentum (i.e., force) with learner satisfaction was weak, it was still stronger than with changes in betweenness-based distance and learner satisfaction. Therefore, force is the preferred choice as one of the structural core variables.

Social Networks: Three Types of Distance

Recently, Kossinets and Watts (2006) concluded that electronic social networks evolved over time. While their study examined time-stamped e-mails of 40,000 adult learners at a university during a nine month period, this study examined discussion board text over a smaller time period, but elaborated on three different measures of distance which described learner connectivity in different ways.

Degree-based distance is a measure of how many direct ties (links) a learner has with other learners in the class, and thus reflects the number of choices and opportunities to communicate with other learners. Therefore, the degree-based distance of a learner indicates the extent to which a learner may be constrained by, or constrain other learners (Hanneman & Riddle, 2005) by the number of direct connections to other learners. In essence, degree-based distance is a measure of power, since the more direct ties a learner has, the more reach and power s/he has (Bonacich, 1987). Since there were no statistically significant changes in degree-based distance from mid-semester to the end of the semester, the average amount of power a learner retained on the discussion boards did not change. The extent to which a learner can reach others on the discussion boards may help describe their opportunity structure (the total of opportunities offered by the system and its environment), a concept that was recently applied to social network theories (Hanneman & Riddle, 2005). In earlier literature, the expression "opportunity structures" was used to describe the conditions in which people were engaged in collective action and in studies of the causes of social movements (Kriesi, Koopmans, Duyvendak, & Giugni, 1992).

Unlike degree-based distance, closeness-based distance doesn't have the limit of considering only direct ties to other learners, as it considers all learners in the network. Closeness-based distance increased significantly from mid-semester to the end of semester. Since the effect size was large (Cohen's $d = 0.53$) and the correlation between mid-semester and end of semester distance scores was high ($r = 0.916$), the learners became considerably "closer" (i.e., more accessible) to each other during the second eight-week period of the semester. Closeness-based distance measured how easily and

therefore how quickly a learner can access all other learners through text messages on the discussion boards as a result of a learner's position in the network. Access to other learners in the network gave an individual access to new information and the ability to create and share knowledge (Cross, Parker, Prusak, & Borgatti, 2001).

Location in the network is an aspect of structural advantage, since being "closer" to other learners in the network than others are to each other, gives an individual more influence and power. Since the aspect of power from the degree-based distance values didn't change over this time period, it would indicate that a learner's influence over less directly connected learners is what increased. This indicates that the network has evolved as more learners have increased the number of weak ties. Granovetter (1980) indicated that individuals with fewer weak ties will more likely be deprived of information from distant parts of the network which may put them in a disadvantaged position. As more learners increase their weak ties, the strength of the social network increases.

Betweenness-based distance measures how often the learner is on the path between other learners. In other words, the control a learner has over the text that flows on the discussion boards between two other learners. Betweenness-based distance demonstrates the ability of a learner to broker information and control communication between other learners (Zemljič & Hlebec, 2005; Freeman, 1979), and that by removing him/herself from the network, the learner potentially disrupts the flow of information.

Contrary to the closeness-based distance measurements, the betweenness-based distance value dropped significantly from mid-semester to the end of semester. The statistically significant Wilcoxon signed ranks test coupled with a strong correlation

suggested that the level of control of information that individual learners had decreased from mid-semester to the end of semester.

Therefore, the amount of learner power remained relatively constant, the degree of learner access increased and the level of learner control decreased. Each social network parameter yielded completely different results for this sample of learners. The ability to differentiate between these aspects of learner centrality made SNA a useful tool for examining asynchronous communication patterns in online discussion boards.

Momentum

Similar patterns across time emerged for momentum as they did for distance, although the increase in closeness-based momentum was not significant. Degree-based momentum and closeness-based momentum scores did not significantly change from mid-semester to the end of semester, but betweenness-based momentum scores decreased significantly during the same time period. Correlations from mid-semester to the end of semester for betweenness-based momentum scores were moderately high (rho > 0.68) which indicated that students were maintaining their relative positions (ranks) within the sample from mid-semester to end of semester. While it is difficult to generalize these results to the online learner population due to the demographics and size of the sample, one outcome is clear: Betweenness-based momentum can be used to assess and differentiate communication patterns on online discussion boards across time for small samples of learners.

It is meaningful at this point to extend the interpretations of the social network parameters of distance (Hanneman & Riddle, 2005) to those of momentum. Since betweenness-based distance measures the control a learner has over the text that flows on

the discussion boards, then betweenness-based momentum is a gauge of how much control the learner has over a given amount of text flowing on the discussion boards at a given rate. Any change in betweenness-based momentum over a given period of time (e.g., mid-semester to end of semester) would reflect a change in learner control over the flow of text. Recently, Barthélemy (2004) used betweenness-based centrality to analyze nodes in large complex networks. Barthélemy reported that these networks can be classified as either exponential or scale-free networks depending on the rate of decay (loss of nodes) as fast or slow respectively. This would provide a functional relationship of distance with time, and therefore could examine how learner control of information changes over a given time period. Naturally, this requires tracking activity on a continuous basis which would require a large amount of resources, but would be interesting future research given the appropriate resources.

Note that conceptual parallels can be constructed for the other two momentum values generated from the fundamental variables of mass, time, and distance. Degree-based momentum is a reflection of how many ties (links) a learner has with other learners in the class and how much text flows through those ties at a given rate. Closeness-based momentum is a measure of how easily a learner can access a given amount of text that is available on the discussion boards at a given rate. Therefore, all three forms of momentum are measures of rate, but are differentiated from one another through aspects of control (betweenness-based), number of ties (degree-based), and access (closeness-based) that the learner has on the discussion boards.

On initial inspection, it might seem that using any one of the three distance values (degree, closeness, or betweenness) might be preferred to using momentum values as

they required fewer resources to determine (i.e., the parameter of momentum requires measurements in mass and time, but the parameter of distance does not). However, aside from the conceptual difference between distance and momentum, correlations of distance and average learner satisfaction proved to be lower than correlations of momentum with average learner satisfaction, thereby making the use of momentum a better choice for a predictor variable in the structural core model. Choosing the value of distance would be useful if resources are scarce for the assessor.

Force

As indicated in chapter III, differences in momentum are directly proportional to the external forces that cause these differences. Therefore, the values for the differences in momentum reported in chapter IV are a quantitative measure of external forces that will change a learner's momentum from mid-semester to end of semester. Since it was reported that only betweenness-based momentum produced significant changes from mid-semester to the end of the semester, these values were used to illustrate the differences in momentum across this eight-week time period. The average force was negative for the sample: M (SD) = -68 (181). This negative force indicated a net loss in momentum from mid-semester to the end of the semester, which wasn't unusual since many courses have projects and/or final exams at the end of the semester (Schunk & Zimmerman, 1997), which can detract a large amount of learner momentum used for the discussion boards. Consequently, it was not surprising to see a small decrease in overall momentum from mid-semester to the end of the semester, and that force was weakly, but significantly correlated to learner satisfaction.

The force that learners reported as having had the most negative impact on getting their coursework done was their other courses. Most of the items from section II-C on the learner satisfaction survey indicated that, on average, external forces (e.g., jobs, social life, other courses, etc.) had a small effect on getting their coursework done which would explain the decrease in momentum from mid-semester to the end of the semester. These results supported ongoing literature that reported how industrious adult learners use the flexible nature of online learning (Beeghly, 2005; Stacey, Smith, & Barty, 2004) to accommodate their busy lives.

However, the range of force values for individual learners was quite large, -773 to +128, and that variability across learners was high. This indicated that some learners were increasing their momentum on the discussion boards from mid-semester to the end of the semester, which partially offset for those learners who are decreasing their momentum.

Energy

Kinetic energy, like the parameter of momentum, is both functionally dependent on the three fundamental variables of mass, time, and distance, but the level of dependency on time and distance is greater for kinetic energy (Wolfson & Pasachoff, 1995). Not surprisingly, patterns in kinetic energy were very similar to the patterns in momentum when measured from mid-semester to the end of the semester. Degree-based kinetic energy and closeness-based kinetic energy did not significantly change during this time period, but betweenness-based kinetic energy significantly decreased.

Potential energy was found not to significantly change from mid-semester to the end of the semester. Experimental data that uses physical models of mechanical energy will

often illustrate that as the kinetic energy of a system increases, potential energy decreases (and vice versa). If this relationship of kinetic energy and potential energy is not observed, the energy model is incomplete and alternative sources of energy are examined (e.g., thermal, acoustical, deformational, etc.) to see if their inclusion can improve the precision of the model (Rojo, 2005). This suggests that perhaps another form of energy (e.g., thermal energy) might be needed to more precisely model the energy components of this study. If kinetic energy indicates activity on the discussion boards due to learners responding to text, and potential energy is a lack of activity due to learners not responding to text, then thermal energy could be the result of interpersonal friction developing between learners due to activity levels or content of messages. In other words, interpersonal disagreement between learners could be an additional variable used to account for discussion board activity levels. A variable that measures the level of disagreement amongst learners could be used as a way to determine this missing energy component.

Main Predictor Variables and Learner Satisfaction

Momentum and Learner Satisfaction

The idea for this study originally developed from two sources: (1) literature on the importance of adult learner satisfaction (Noel-Levitz, 2005) and interactivity in online courses (Picciano, 2002; Hacker, 1996), and (2) observations of online learner behavior and attitudes, specifically discussion board activity and learner satisfaction. Personal experience from the natural sciences and participation in online courses suggested that physical parameters such as momentum (Tonfoni, 1996) would be a good representation of interactivity and would make an ideal core variable for this study.

It was not surprising that there was a strong quantitative relationship between learner momentum and learner satisfaction. It seemed unusual that the fundamental variables of mass and time had no statistically significant relationship with learner satisfaction. However, the ratio of mass/time and two forms of distance did significantly correlate with learner satisfaction, but not to the same magnitude as momentum and learner satisfaction did. Therefore, from the analysis of data collected in this study, it is most appropriate to associate learner momentum to learner satisfaction as part of the core model and to ignore the fundamental variables of mass and time. In essence, the relationship of momentum and learner satisfaction indicated that the more interactive a learner is on the discussion boards, the more satisfied s/he is with the discussion board experience. There was no point of limiting returns for this relationship since systematic removal of very high or low scores of momentum did not increase the correlations of learner momentum and learner satisfaction. Thus, within the limits of time for this study, learner satisfaction was not found to level off or decrease as momentum values increased.

Two patterns emerged from the analysis of learner momentum and learner satisfaction: (1) correlations of any form of learner momentum (degree-based, closeness-based, or betweenness-based) with average learner satisfaction values are always higher than with overall learner satisfaction values, and (2) correlations of either form of learner satisfaction (overall or average) with learner momentum decreases in magnitude from degree-based momentum to closeness-based momentum to betweenness-based momentum. The strongest relationship established was between degree-based momentum and average learner satisfaction at the end of the semester (rho = 0.801). In fact, this is the strongest relationship established in the structural core or high precision

models of this entire study. Therefore, this relationship is the most powerful and representative link in the core model and suggests that attitudes and behaviors within the context of discussion boards of online courses can be strongly associated.

Typically, associations of attitudes and behaviors are only moderately related in strength (Ajzen & Fishbein, 1980). While the evidence in this study will not provide a causal mechanism for the model, it is evident that a person cannot be satisfied with an experience until s/he has had the experience (Dabholkar, 1995). However, a feedback loop can develop and the subsequent learner satisfaction may provide the impetus for greater learner momentum, and so forth.

Force and Learner Satisfaction

The correlation of force from mid-semester to end of semester with learner satisfaction scores are negative and generally weak (rho = -0.2 to -0.4). In fact, while the association of force and learner satisfaction is statistically significant, it is still the weakest link of the core model. This is not surprising because momentum (consistent motion) is strongly correlated with learner satisfaction and force is directly related to changes in momentum. If force (changes in consistent motion) was strongly correlated to learner satisfaction over the same range of values, this would probably be incompatible with the strong momentum/satisfaction relationship.

However, correlations of either degree-based force or betweenness-based force with learner satisfaction are statistically significant, and therefore become part of the structural core model. Therefore, as the force decreases (i.e., momentum becomes lower at the end of the semester with respect to mid-semester) the learner satisfaction increases. This suggests that learners are more satisfied with their overall experience as their activity on

the discussion board decreases from mid-semester to the end of the semester. Increasing attrition and fatigue could act as external forces and account for the decrease in momentum since they have been associated with learner dissatisfaction (Roszkowski & Ricci, 2005). Decreasing momentum would offset attrition and fatigue and therefore be associated with higher learner satisfaction.

Based on the law of the conservation of energy and the grand unified theory of forces, Podolinsky (2004) had reported that the transposition of certain human forces as applied to labor is directly proportional to the satisfaction of human needs. While his research was conducted within a socio-economical framework, his theoretical connections between physical forces and human behavior supports the abstraction of communication constructs created from physical parameters used in this study, and their subsequent relationship to learner satisfaction. The mediating relationship of labor between human forces and human satisfaction suggested that the precision of this study's model would improve by including a variable of labor as a mediator variable. That is to say, assessment of work input would provide a more comprehensive model, and the parameter of work already exists in the physical sciences and is related to energy via the first law of thermodynamics. This could provide the opportunity for further research into using physical parameters to explain human behavior and their association to human attitudes.

Energy and Learner Satisfaction

Degree-based kinetic energy scores correlate moderately and positively with learner satisfaction ($r = 0.5$). Remaining correlations where kinetic energy values depend on the distance values of closeness or betweenness are lower or not statistically significant. Potential energy scores correlate negatively with learner satisfaction and are also

moderate in strength ($r = -0.5$). Collectively, these two sets of correlations indicate that learner satisfaction increases with activity on the discussion boards and that learner satisfaction decreases with inactivity on the discussion boards. It's important to report these two correlations collectively because learners will perceive activity and inactivity from their peers separately and simultaneously (Jeong, 2003). It's possible in some online courses that a small percentage of the learners are doing most of the communicating on the discussion boards, making it very active, while others fail to participate to any significant degree, making it simultaneously inactive. Likewise, some learner's messages may get responded to in large amounts, while others get little or no response at all. In essence, the level of activity can be examined for individual learners as sinks or sources and that some learners create a more satisfying experience for others by interacting with them more, yet some learners may interact very little with their classmates, which cause the satisfaction to decrease for the latter.

Core Model of Learner Satisfaction

As illustrated in chapter IV, the core model consisting of statistically significant Spearman correlations ($p < 0.05$) includes all bivariate relationships between the main predictor variables and average learner satisfaction. Although this was not a causal (experimental) study, it did treat average learner satisfaction as an outcome variable, which required a linear regression model to fit the data. Fortunately, momentum and potential energy were established as predictor variables for average learner satisfaction. Unfortunately, force was not a significant predictor variable in the regression model. Considering the low correlation between force and average learner satisfaction, this is not surprising. However, a significant relationship was found between force and learner

satisfaction through a bivariate correlation, but it was overpowered by the other main predictor variables in the linear regression model.

In summary, momentum and kinetic energy were positively associated with learner satisfaction. Force and potential energy were negatively associated with learner satisfaction. Therefore, learners who were more active in communicating in online discussion boards as seen through higher levels of momentum and kinetic energy were more satisfied with their experience. Conversely, learners who were less active in communicating in online discussion boards as seen through higher levels of potential energy were less satisfied with their experience. Furthermore, learners who decreased their online asynchronous communications from mid-semester to the end of the semester as seen through force measurements were more satisfied with their experience. Roszkowski and Ricci (2005) had recently reported that it was just as important to determine what variables decrease learner satisfaction as well as those that increase learner satisfaction.

Moderator and Mediator Variables and the Precision Model

In order to provide a more precise model for learner satisfaction in this study, additional variables were examined as potential moderator or mediator variables, and were then added to the core model. While some of the examined variables did meet the statistical requirements as a moderator or mediator variable for the learner satisfaction model, complications arose due to multicollinearity and/or the variable acting as a separate predictor variable. The following sections discuss the results of the variables examined for inclusion in the precision model as potential moderator and/or mediator variables.

Learner Prior Experience

Learner experience and learner satisfaction have been positively associated as reported in recent literature (El Ansari & Oskrochi, 2004). Further examination needs to be conducted on how learner prior experiences affect learner satisfaction, particularly in an online environment where changes have occurred rapidly in design and development (Oblinger & Hawkins, 2006; Koehler, Mishra, Hershey, & Peruski, 2004). Knowledge of learner's prior online experiences will help instructors design and prepare online courses that learners will be more satisfied with (Lao & Gonzales, 2005).

Learner prior experience was quantitatively measured by the number of previous courses the learner had taken and was determined to be a moderator variable for kinetic energy in the learner satisfaction model. However, there was evidence from the linear regression model that learner prior experience could be used directly as a predictor variable for learner satisfaction as well. This indicated that increased levels of prior learner experience will increase the kinetic energy (activity) and satisfaction of the learner. As a predictor variable this directly impacts learner satisfaction and as a moderator variable it indirectly affects learner satisfaction through kinetic energy. Furthermore, the weak yet statistically significant relationship between learner prior experience and kinetic energy indicates a low level of multicollinearity, which decreases the statistical power of the linear regression. In essence, this suggests that higher levels of learner prior experience with online courses allowed those learners to be more active on the discussion boards due to their previous experience. Greater activity on the discussion boards means greater kinetic energy and therefore greater learner satisfaction. The fact that learner prior experience was determined to be a moderator variable and

predictor variable, as well as related to kinetic energy is not surprising (El Ansari & Oskrochi, 2004).

Thompson and Ku (2005) recently reported that the quality of a learner's experience should be examined as well as the quantity of their experience. This would give broader insight into why learners may or may not be satisfied with their past experiences and how that would be associated with their satisfaction of their present experience. However, their research was based on interviews of a small (N=7) sample of doctoral students, which made comparative analysis and generalization difficult. A reliable, multidimensional survey on prior learner experience that could be factored from multiple components would provide greater insight into this study's precision model.

A useful component for future research would investigate how past and present levels of learner experience and past and present levels of satisfaction are all related to one another. The next section will examine how past levels of learner satisfaction impact the core model of satisfaction of this study.

Learner Prior Satisfaction

Learner prior satisfaction was determined to be a moderator variable for potential energy. Since the beta weight for the interaction term between learner prior satisfaction and potential energy in the linear regression was negative, it can be concluded that as the value of the interaction decreases, learner satisfaction increases. In essence, the learner is more satisfied when the higher values of learner prior satisfaction are linked to lower values of potential energy. Therefore, learners with higher prior satisfaction that maintain low levels of inactivity are more satisfied with their discussion board experience.

There was no statistical association between learner satisfaction and learner prior satisfaction. While this is helpful in establishing the credibility of learner prior satisfaction as a moderator variable in this study, it does seem highly unusual that there is no link to the outcome variable. Perhaps the experiences for each online course are perceived as independent of one another by the learner. Hence, any prior attitudes towards online learning do not directly affect the attitudes (such as satisfaction) a learner has towards a given course. Since the learners come in with different experiences with online courses (e.g., number of online courses previously taken, level of courses, content of courses), it's not surprising that there is no direct connection between learner prior satisfaction and learner satisfaction.

Perhaps what is needed is to assess the importance of the learner's prior experiences as well as their satisfaction. Roszkowski and Ricci (2005) had indicated that satisfaction surveys should contain an importance scale because dissatisfaction with the less important components of coursework is not as problematic as dissatisfaction with more important components. If students participated in online courses that weren't important to them, than perhaps, their level of satisfaction with those courses are unimportant and have no bearing on future levels of satisfaction.

Conclusion

In conclusion, the core model was expanded to include additional moderator variables such as learner prior experience and learner prior satisfaction. Adding the secondary variables to the three main predictor variables (momentum, force, and energy) and the outcome variable of learner satisfaction in the core model created a more complete model to address the three research questions of this study. The core model is a more useful

learner satisfaction model when resources such as time are scarce, but the precision model provides a more comprehensive model that can take into account greater aspects of variability and how the main predictor variables are moderated or mediated.

Implications for Teaching and Learning

In response to Wang (2003), this study provides instructors with a factorable, reliable, and valid multi-component learner satisfaction survey that can be used for discussion boards in online courses. Furthermore, the models generated in this study help instructors of online courses predict learner satisfaction from the level of interactivity on the discussion boards, which as of this writing has not been produced in the literature. Since higher levels of interactivity were associated with higher levels of learner satisfaction, teachers and learners may want to identify those conditions that led to these levels. Interactivity includes only those communications which occur through learner-learner or learner-instructor.

If the conditions that lead to higher levels of interactivity are environmental, then good instructional design will lead to favorable results. It is suggested that discussion board activity be regulated via course syllabus so that abundant and consistent communication is achieved. Fung (2004) reported that learner participation in online courses is impacted by the interactivity level of their peers. Requiring that learners communicate with as many other learners as possible will increase the strength of each learner's social network (Hanneman & Riddle, 2005) and according to this, greater learner satisfaction. Therefore, the instructor should implement regulated levels of interactivity as requirements into his/her course.

Naturally, mandating a quantifiable level of interactivity will not by itself create higher quality interactions. Other components of good instructional design must be considered as well. Levin, Waddoups, Levin, and Buell (2001) stated that using relevant and challenging assignments and developing rich environments for student-to-student interaction were important as well.

As reported by Jin (2005), higher levels of interactivity also contribute to the construction of shared knowledge. The online environment encourages learner-learner interactions and student-centered, self-directed learning, which is a part of the constructivist approach where knowledge is created by the learner. However, this is sometimes seen in opposition to the traditional behavioral approach where instructors prompt information from the learners to achieve desired and measurable outcomes. Achieving measurable outcomes with a constructivist approach is considerably harder since one cannot directly observe the "construction of knowledge." Furthermore, adult education and constructivist theories are rarely discussed in the same piece of literature. However, this doesn't negate the possibility that shared knowledge can be created and measured in online discussion boards.

Naturally, online discussion boards can be used to reinforce self-directed learning, which is a principle component of adult learning. Furthermore, the discussion boards can provide a structured environment without necessarily interfering with an adult learner's quest for relevance and meaning. Boyer (2003) stated that a self-directed learning framework can provide adult, online learners this structure which aids the acquisition of knowledge.

The impetus to interact cannot fall solely on the shoulders of the learners. Instructors must participate on the discussion boards regularly and give timely feedback to the learners (Swan, 2002). Instructors must find a way to balance the instructor-learner and learner-learner interactions so that there is an adequate balance between the structures they provide with the self-directed learning that occurs when adult learners have to act more independently. The results from this study provide a quantifiable measure for communication in online courses and can establish the level of interactivity on individuals as well as entire groups.

The assessment of learner communication need not be limited to the instructor. Releasing the results to the learner could aid his/her awareness of how efficiently they communicate with other members of the course. Revisiting their previously posted messages, learners can critically reflect on their discussions and compare their understanding of the material to how efficiently and effectively they communicated their ideas to other course members. Naturally, learner awareness may moderate or mediate the association of momentum or energy on learner satisfaction which may require a revision of this study's models and would be useful for future research.

Teachers now have a way to determine if learners will be satisfied with their online discussion board experience by simply monitoring their text-based discussions and the level of social networking with other learners. Furthermore, by measuring additional attitudes and behaviors that moderate and/or mediate the volumetric and frequency communication patterns of online discussion boards, instructors have a means to maximize the communication and hence learner satisfaction. The attitudinal and behavioral variables that moderate and/or mediate the communication variables are easy

to measure early in the course. Learner prior experience (behavioral indicator) and prior satisfaction (attitudinal indicator) were shown to moderate either learner momentum or energy in this study. This indicates that the strength of the relationships of momentum (or energy) and learner satisfaction is greater when prior experience and prior satisfaction is accounted for. Naturally, learner prior experience and learner prior satisfaction bring additional aspects of variability that variables of the physical sciences may lack, which helps to strengthen the overall model.

In conclusion, this study provides two learner satisfaction models that can assist instructors of online courses in predicting how satisfied their learners will be based on their communication patterns on the discussion boards. The results that they generate during the semester can be used to improve the learner's behavior and hence their attitude towards their experience by the end of the semester. Satisfied online learners are more likely to return as future consumers of online courses and discuss their positive experiences with other people they know, thus encouraging future growth in their program.

Future Research

External Forces

Since this study discovered that a small decrease in learner momentum from mid-semester to the end of the semester was associated with an increase in learner satisfaction, further investigation into why this happened is needed. This association suggested that internal (e.g., attrition, change in motivation, etc.) or external (e.g., employment, other courses, social support, etc.) forces are causing the learner to reduce their interactivity on the discussion boards over this time period. While this study had

asked the learners (as an optional survey item) to identify any forces that may have impacted their satisfaction with their course, it didn't quantify them due to limitations in response and survey size.

Kemp (2002) had recently reported that the persistence of adult learners in online courses may be dependent on the presence of these two types of forces. She also indicated that beliefs in personal ability and self-efficacy would indicate how persistent adult learners would be in completing their objectives, despite these forces. This would require additional outcome variables such as learner success to be measured (which can be assessed as a learner perception or performance), that could mediate or moderate the factors in this model.

Reio and Crim (2006) recently stated that there is a need to examine the relationships between social presence, retention in online courses, perceived learning, and learner satisfaction. The authors suggested that incorporating social presence into online courses could improve outcomes such as retention, learning, and learner satisfaction, particularly since CMC is considered to be a medium that is low in social context cues (Gunawardena, 1995). Since interactivity (a variable that this study addressed), along with immediacy (psychological distance between learners who are communicating) and intimacy (sense of closeness between learners), form the construct of social presence, the results of this study will be beneficial in addressing these relationships. However, perceptions of CMC as a social medium will depend on the quality of interactions that take place between the learners, and the sense of community that is created in the online course that they participate in. This study focused primarily on the quantity of interactions, not the quality of them.

Time Management

Since it was determined that external forces altered the learner's momentum over the semester and that it impacted learner satisfaction, it would be prudent to assess how learner's manage their time in online courses. Learners who manage their time will maintain a more constant, higher level of momentum, and can lead to greater learner satisfaction. In addition, learners who manage their time well will reduce stress and missed course deadlines. Using their time more productively on a regular basis can facilitate success and greater performance for most learners (Northam, 2005).

Instructional Design

While not presented as results in this dissertation, some preliminary investigation into instructional design issues was conducted. It was discovered that: (1) the presence of a course orientation/introduction, (2) number of required postings per module, and (3) course strategy/educational model of the course (behavioral/cognitive/constructivist) moderated the effects of momentum on learner satisfaction. It was also determined that instructional design components of learning objectives present in syllabus and testing in the course did not impact the core model of this study. Swan (2001) had recently reported that interaction with instructors, clarity of design, and active discussion among course participants significantly influenced learner's satisfaction. Swan's results, along with the preliminary unreported findings from this study on the effects of instructional design on interactivity and learner satisfaction should be continued.

Learner Performance

Learners ultimately want to know what it takes to be successful in their online courses. Since many instructors require learners to participate on the discussion boards (an

instructional design issue) learners would want to know how to effectively communicate with each other. Future research into the association of learner performance (e.g., learner grades and test scores) with communication patterns will help inform instructors and learners what works best. If the communication patterns and the learner's performance can be monitored on a weekly basis, formative feedback can be used to help the learner improve their communication and performance and help the assessor improve the relationship between the two variables.

Parameters of the Natural Sciences

More work could be done in creating conceptual models that utilize parameters of the natural sciences in the social sciences. Measurable physical parameters such as pressure, power (change in energy over time), work (force applied through distance), and even entropy (disorder) have entered into the mainstream language but are rarely measured within the context of the social sciences. Since the physical models have held up under rigorous testing in the natural sciences, they can provide users with strong structural models that can expand to explain human behavior and attitudes.

Conclusion

This study provided results that the learner interactions that occur in online discussion boards were strongly associated with learner satisfaction. Ultimately, this provides instructors a way to predict how satisfied learners will be based on how they communicate with each other in this medium.

The learner satisfaction survey contributes to the gap in the research literature pointed out by Wang (2003) who indicated that such a form had not been fully developed for asynchronous communication.

This study also provided a unique, interdisciplinary method of creating communication constructs from physical parameters used in the natural sciences and social parameters used in SNA. The core model, which consisted of the main predictor variables of momentum, force, and energy and the outcome variable of learner satisfaction, was later expanded to include two additional moderator variables in the precision model. While the core model can illustrate the relationships between the main predictor variables and learner satisfaction, some of the variability would be more comprehensively described by additional attitudinal and behavioral variables which moderate the relationships of the core model.

The relationship of learner momentum and learner satisfaction was the strongest relationship in the core model. This indicated that as the learners interacted more often with each other and with greater numbers of their classmates, they were more satisfied with their experience with the discussion boards. While this relationship was strong at mid-semester and at the end of the semester, the overall momentum decreased during this time. This change in momentum, which was characterized as force, also had a statistically significant albeit somewhat weaker relationship with learner satisfaction. Learner kinetic energy and learner potential energy, which characterized learner activity and learner inactivity respectively, were both related to learner satisfaction. This indicated that learner satisfaction increased with increasing activity on the discussion boards, and decreased with increasing inactivity. Kinetic energy and potential energy were measured as two distinct variables as it was possible to have high levels of activity from some learners, and high levels of inactivity from other learners, both of which impacted their level of satisfaction.

In summary, the learner satisfaction models developed in this study help researchers, instructors and learners understand that there is a strong relationship between discussion board activity of online courses and learner satisfaction.

REFERENCES

Abdullah, M. H. (2003). The impact of electronic communication on writing. ERIC Digest. ED477614. Retrieved April 5, 2006 from http://www.eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=ED477614.

Accreditation. (2003). Accreditation of higher education institutions: An overview, 2003 edition. Retrieved April 5, 2006 from http://www.ncahlc.org/download/2003Overview.pdf.

Ainsworth, D. (2000). The unbearable cost of interaction, in University of South Australia. September 2002 Conference Proceedings. *Distance Education: An Open Question?* University of South Australia, Adelaide.

Ajzen, I., Fishbein, M. (1980). Understanding the attitudes and predicting social behavior. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Arbaugh, J. B. (2000). How classroom environment and student engagement affect learning in Internet-based MBA courses. *Business Communication Quarterly, 63* (4), 9-26.

Astin, A. W. (1993). Assessment for excellence: The philosophy and practice of assessment and evaluation in higher education. Phoenix: The Oryx Press

Atack, L., Rankin, J. (2002). A descriptive study of registered nurses' experiences with web-based learning. *Journal of Advanced Nursing, 40,* 457-465.

Aviv, R., Erlich, Z., Ravid, G., & Geva, A. (2003). Network analysis of knowledge construction in asynchronous learning networks. *Journal of Asynchronous Learning Networks, 7* (3), 1-23.

Ajzen, I., Fishbein, M. (1980). Understanding attitudes and predicting social behavior.

Englewood Cliffs, NJ: Prentice-Hall.

Badalamenti, A. F., Langs, R. J. (1992). The thermodynamics of psychotherapeutic communication. *Behavioral Science, 37* (3), 157-180.

Ballard, D., Seibold, D. R. (2004). Communication-related organizational structures and work group temporal experiences: the effects of coordination method, technology type, and feedback cycle on members' construals and enactments of time. *Communication Monographs, 71* (1), 1-27.

Barley, S. (1988). On technology, time and social order: Technically induced change in the temporal organization of radiological work. In *Making time: ethnographies of high-technology organizations,* Ed. Frank A. Dubinskas, pp. 123-169. Philadelphia: Temple University Press.

Baron, R. M., Kenny, D. A. (1986). The moderator-mediator variable distinction in social-psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51* (6), 1173-1182.

Barthélemy, M. (2004). Betweenness centrality in large complex networks. *The European Physical Journal B, 38,* 163–168.

Beaudin, B. (1999). Keeping online asynchronous discussion on topic. *Journal of Asynchronous Learning Networks, 3* (2), 41-53.

Beeghly, D. G. (2005). It's about time: Using electronic literature discussion groups with adult learners. *Journal of Adolescent & Adult Literacy, 49* (1), 12-21.

Berger, I. E., Mitchell, A. A. (1989). The effect of advertising on attitude accessibility, attitude confidence, and the attitude-behavior relationship. *Journal of Consumer Research, 16* (3), 269-279.

Berkowitz, S. D. (1982). An introduction to structural analysis: The network approach to social research. Toronto: Butterworths.

Berners-Lee, T., Cailliau, R., Groff, J-F., & Pollermann, B. (1992). World-wide web: The information universe. *Electronic Networking, 2* (1), 52-58.

Biesenbach-Lucas, S. (2003). Asynchronous discussion groups in teacher training classes: Perceptions of native and non-native students. *Journal of Asynchronous Learning Networks, 7* (3), 24-46.

Billings, D. M., Connors, H. R., & Skiba, D. J. (2001). Benchmarking best practices in web-based nursing courses. *Advances in Nursing Science, 23* (3), 41-52.

Bjarnason, S. (2003). Evolution or revolution? Information and communication technologies in higher education. *Perspectives: Policy & Practice in Higher Education, 7* (4), 110-113.

Bloom, B. S. (1956). Taxonomy of Educational Objectives: The Classification of Educational Goals: Handbook I, Cognitive Domain. Toronto: Longmans.

Bohnenkamp, D. (1989). Post-Einsteinian physics and literature: Toward a new poetics. *Mosaic, 22* (3), 19-30.

Bonacich, P. (1987). Power and centrality: A family of measures. *American Journal of Sociology, 92,* 1170-1182.

Booker, M. K. (1990). Joyce, Planck, Einstein, and Heisenberg: A relativistic quantum mechanical discussion of Ulysses. *James Joyce Quarterly, 27,* 577-586.

Borgatti, S. P., Everett, M.G. & Freeman, L.C. (2002). Ucinet for windows: Software for social network analysis. Harvard, MA: Analytic Technologies.

Boyer, N. R. (2003). The learning contract process: Scaffolds for building social, self-

directed learning. *The Quarterly Review of Distance Education, 4* (4), 369-383.

Boyle, G. J. (1991). Does item homogeneity indicate internal consistency or item redundancy in psychometric scales? *Personality & Individual Differences, 12,* 291-294.

Browne, E. (2003). Conversations in Cyberspace: a study of online learning. *Open Learning, 18* (3), 245-259.

Bucy, E. P. (2004). Interactivity in society: Locating an elusive concept. *Information Society,* 20, 373-383.

Burge, E. (1994). Learning in computer conferenced contexts: The learners' perspective. *Journal of Distance Education, 9* (1), 19-43.

Campbell, D. R., Fiske, D. W. (1959). Convergent and discriminant validation by multitrait-multimethod matrix. *Psychological Bulletin, 56* (2), 81-105.

Campbell, J. W., Blakely, L. S. (1996). Assessing the impact of early remediation in the persistence and performance of underprepared community college students. Paper presented at the 36th Annual Forum of the Association for Institutional Research, May 5 - 8, Albuquerque, NM. ERIC ED 397749.

Cappella, J., Price, V., Nir, L. (2002). Argument repertoire as a reliable and valid measure of opinion quality: electronic dialogue in campaign 2000. *Political Communication, 19,* 73–93.

Carmines, E. G., Zeller, R.A. (1991). Reliability and validity assessment. Newbury Park: Sage Publications.

Chaudier, A. (2004). Successful communication. *Supervision, 65* (11), 7.

Chersky, J. (2003). What Is Time? *Journal of the American Society for Information*

Science & Technology, 54 (11), 1078-1082.

Collis, B., van der Wende, M. (2002). Models of technology and change in higher education (The Netherlands, Center for Higher Education Policy Studies). Retrieved April 5, 2006 from http://www.utwente.nl/cheps/documenten/ictrapport.pdf.

Coren, S., Ward, L. (1989). Time and motion. From Sensation and Perception. Harcourt Brace: New York.

Crino, M. D., White, M. C. (1981). Satisfaction in communication: An examination of the Downs-Hazen measure. *Psychological Reports, 49,* 831-838.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of the tests. *Psychometrika, 16,* 297-334.

Cross, R., Parker, A., Prusak, L., Borgatti, S. P. (2001). Knowing what we know: Supporting knowledge creation and sharing in social networks. *Organizational Dynamics, 30* (2), 100-120.

Crouch, B. S., Hellweg, S. A. (1989, February). Subordinate communication satisfaction as a function of superior-subordinate co-orientation regarding performance feedback rules. Paper presented at the Annual Meeting of the Western Speech Communication Association, Spokane, WA.

Crow, G., Heath, S. (2002). Social conceptions of time: Structure and process in work and everyday life. Basingstoke: Palgrave.

Dabholkar, P. A. (1995). A Contingency Framework for Predicting Causality between Customer Satisfaction and Service Quality. *Advances in Consumer Research, 22,* 101-108.

Day, J. M., O'Donovan, K. (1988). Online education and marketing: A joint approach. *Education for Information, 6* (3), 315-322.

De Wever, B., Schellens, T., Valcke, M., Van Keer, H. (2006). Content analysis schemes to analyze transcripts of online asynchronous discussion groups: A review. *Computers and Education, 46* (1), 6-28.

Debourgh, G. A. (1998). Learner and instructional predictors of student satisfaction in a graduate nursing program taught via interactive video conferencing and world wide web/Internet. Unpublished doctoral dissertation, Northern Arizona University.

Delli Carpini, M., Cook, F. L., Jacobs, L. R. (2004). Public deliberation, discursive participation, and citizen engagement: A review of the empirical literature. *Annual Review of Political Science, 7* (1), 315-344.

Dennis, J. (2003). Problem-Based learning in online vs. face-to-face environments. Education for Health: *Change in Learning & Practice, 16* (2), 198-209.

Dinges, D. F. (2001). Stress, fatigue, and behavioral energy... Defining energy for a new millennium. *Nutrition Reviews, 59,* S30-32.

Doll, W. J., Raghunathan, T. S., Lim, J. U., Gupta, Y. P. (1995). A confirmatory factor analysis of the user information satisfaction instrument. *Information Systems Research, 6* (2), 177-189.

Downs, C. W. (1988). Communication audits. Glenview, Illinois: Scott Foresman.

Downs, C. W., Hazen, M. D. (1977). A factor analytic study of communication satisfaction. *The Journal of Business Communication, 14* (3), 63-73.

Downes, E. J., McMillan, S. J. (2000). Defining interactivity: A qualitative identification

of key dimensions. *New Media & Society, 2* (2), 157-179.

Einstein, A. (1920). Relativity: The special and general theory. New York: Henry Holt.

El Ansari, W., Oskrochi, R . (2004). What really affects health professions students' satisfaction with their educational experience? Implications for practice and research. *Nurse Education Today, 24* (8), 644-655.

Elliott, K. M., Shin, D. (2002). Student satisfaction: An alternative approach to assessing this important concept. *Journal of Higher Education Policy and Management, 24* (2), 197-209.

Faust, K., Skvoretz, J. (2002). Comparing networks across space and time, size and species. *Sociological Methodology, 32,* 267-299.

Faust, K., Willert, K. E., Rowlee, D. D., & Skvoretz, J. (2002). Scaling and statistical models for affiliation networks: Patterns of participation among Soviet politicians during the Brezhnev era. *Social Networks, 24,* 231-259.

Fazio, R.H., Powell, M., Williams, C. (1989). The role of attitude accessibility in the attitude-to-behavior process. *Journal of Consumer Research,* 16, 280-289.

Fazio, R. H., Roskos-Ewoldsen, D. R. (1994). Acting as we feel: When and how attitudes guide behavior. In S. Shavitt & T. C. Brock (Eds.), Persuasion: Psychological insights and perspectives (pp. 71-93). Needham Heights, MA: Allyn & Bacon.

Feldt, L. S., Woodruff, D. J., and Salih, F. A. (1987) Statistical inference for coefficient alpha. *Applied Psychological Measurement, 11* (1), 93-103.

Fichter, D. (2005). The Many Forms of E-Collaboration: Blogs, wikis, portals, groupware, discussion boards, and instant messaging. *Online, 29* (4), 48-50.

Fitzgerald, G. A., Desjardins, N. M. (2004). Organizational values and their relation to

organizational performance outcomes. *Atlantic Journal of Communication, 12* (3), 121-145.

Freeman, L. C., Webster, C. M. (1994). Interpersonal proximity in social and cognitive space. *Social Cognition, 12,* 223-247.

Freeman, L. C. (1984). The impact of computer based communication on the social structure of an emerging scientific specialty. *Social Networks, 6,* 201-221.

Freeman, L. C. (1979). Centrality in social networks: Conceptual clarification. *Social Networks, 1,* 215-239.

Freeman, L. C. (1978). Segregation in social networks. *Sociological Methods and Research, 6* (4), 411-429.

Frey, B. A. (2003). Applying adult learning theory to the online classroom. *New Horizons in Adult Education, 17* (1), 4-12.

Fung, Y. Y. H. (2004). Collaborative online learning: Interaction patterns and limiting factors. *Open Learning, 19* (2), 135-149.

Galilei, G. (1632). Dialogue concerning the two chief world systems: the Ptolemaic and the Copernican.

Gardner, P. L. (1995). Measuring attitudes to science: Unidimensionality and internal consistency revisited. *Research in Science Education, 25,* 283-9.

Garrison, R., Anderson, T. (2000) Transforming and enhancing university teaching: stronger and weaker technological influences, in: T. Evans & D. Nation (Eds) Changing university teaching: reflections on creating educational technologies. London, Kogan Page.

Goode, C. M. (2002). Consistency and communication: The benefits of using an online

course management system in a multi-section introductory computing course. In W. Bump (Ed.), The educational computing course. [SITE 2002 Section].

Goldsborough, R., Page, L. (2005). Online discussion groups. *Information Today, 22* (6), 39-40.

Gounard, B. R., Hulicka, I. M. (1977). Maximizing learning efficiency in later adulthood: A cognitive problem-solving approach. *Educational Gerontology, 2,* 417-427.

Granovetter, M. (1980). The strength of weak ties: A network theory revisited. *Sociological Theory, 1,* 201-233.

Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology, 6,* 1360-1380.

Gray, J., Laidlaw, H. (2004). Improving the measurement of communication satisfaction. *Management Communication Quarterly, 17* (3), 425-448.

Greenbaum, H. H., Clampitt, P., Willihnganz, S. (1988). Organizational communication: An examination of four instruments. *Management Communication Quarterly, 2* (2), 245-282.

Gregson, T. (1991). The separate constructs of communication satisfaction and job satisfaction. *Educational & Psychological Measurement, 51* (1), 39-48.

Grondin, S. (2001). From Physical Time to the First and Second Moments of Psychological Time. *Psychological Bulletin, 127* (1), 22-44.

Gunawardena, C. N. (1995). Social presence theory and implications for interaction and collaborative learning in computer conferences. *International Journal of Educational Telecommunications, 1,* 147-166.

Gutek, B. A. (1978). On the accuracy of retrospective attitudinal data. *Public Opinion Quarterly, 42,* 390–401.

Guzdial, M., Carroll, K. (2002). Explaining the Lack of Dialogue in Computer-Supported Collaborative Learning. CSCL 2002 Information and Conference Papers. Retrieved April 5, 2006 from http://newmedia.colorado.edu/cscl/18.html.

Hacker, K. L. (1996). Missing links in the evolution of electronic democratization. Media, *Culture & Society, 18,* 213-232.

Hafele, J. C., Keating, R. E. (1972). *Science, 177,* 166.

Hägerstrand, T. (1970). What about people in regional science? *Papers of the Regional Science Association, 24,* 7-21.

Hanna, D. E., Glowacki-Dudka, & Conceição-Runlee, S. (2000). Practical tips for teaching interactive online courses. Madison, Wisconsin: Atwood Publishing.

Hanneman, R., Riddle, M. (2005). Introduction to social network methods. Retrieved April 5, 2006 from http://www.faculty.ucr.edu/~hanneman/.

Harpole, T. (1996). Resisting natural and human forces. *Architectural Record, 184* (5), 34-37.

Hassan, R. (2003). The chronoscopic society. New York: Peter Lang Publishing, Inc.

Haythornthwaite, C. (2001). Exploring multiplexity: Social network structures in a computer-supported distance learning class. *The Information Society, 17* (21), 211-226.

Hecht, M. L. (1978). Measures of communication satisfaction. *Human Communication Research, 4* (4), 350-368.

Herod, L-K. (2003). Promoting reflective discourse in the Canadian adult literacy

community: Asynchronous discussion forums. *New Horizons in Adult Education, 17* (1), 13-21.

Hew, K. F., Cheung, W. S. (2003). An exploratory study on the use of asynchronous online discussion in hypermedia design. *E-Journal of Instructional Science and Technology, 6* (1), 1-16.

Hill, G. H., Betz, D. L. (2005). Revisiting the retrospective pretest. *American Journal of Evaluation, 26,* 501-517.

Hinkelmann, K. & O. Kempthorne. (2005). Design and Analysis of Experiments, Volume 2, Advanced Experimental Design. New York: Wiley.

Hoerl, C. (1998). The perception of time and the notion of a point of view. *European Journal of Philosophy, 6* (2), 156-171.

Hogarty, K. Y., Hines, C. V., Kromrey, J. D., Ferron, J. M., Mumford, K. R. (2005). The quality of factor solutions in exploratory factor analysis: The influence of sample size, communality, and overdetermination. *Educational and Psychological Measurement, 65,* 202-226.

Hong, K-S., Kwok-Wing, L., Holton, D. (2003). Students' satisfaction and perceived learning with a web-based course. *Educational Technology & Society, 6* (1), 116-124.

Houen, A. (1998). The secret agent: Anarchism and the thermodynamics of law. *English Literary History, 65* (4), 995-1016.

House, J. D. (1999). The effects of entering characteristics and instructional experiences

and student satisfaction and degree completion: An application of the input-environment-outcome assessment model. *International Journal of Media, 26* (4), 423-434.

Hubbell, C. H. (1965). An input-output approach to clique identification. *Sociometry, 28,* 377-399.

Hurrell, A. C. (2005). Civility in online discussion: The case of the foreign policy dialogue. *Canadian Journal of Communication, 30* (4), 633-648.

Hyperdictionary. (2006). [Online]. Retrieved April 5, 2006 from http://www.hyperdictionary.com/dictionary/time.

Jeong, A. C. (2003). The sequential analysis of group interaction and critical thinking in online threaded discussions. *American Journal of Distance Education, 17* (1), 25-43.

Jin, S. H. (2005). Analyzing student-student and student-instructor interaction through multiple communication tools in web-based learning. *International Journal of Instructional Media, 32* (1), 59-67.

Jones, M., Boltz, M. (1989). Dynamic attending and responses to time. *Psychological Review, 96,* 459-491.

Jung, I., Choi, S., Lim, C., & Leem, J. (2002). Effects of different types of interaction on learning achievement, satisfaction and participation in web-based instruction. *Innovations in Education & Teaching International, 39* (2), 153-162.

Junghyun, K. (2003). Interpersonal Interaction in Computer Mediated Communication

(CMC): Exploratory Qualitative Research based on Critical Review of the Existing Theories. Conference Papers - International Communication Association; 2003 Annual Meeting, San Diego, CA, 1-26.

Kaiser, H. F. (1958). The varimax criterion for analytic rotation in factor analysis. *Psychometrika, 23,* 187-200.

Kemp, W. C. Persistence of adult learners in distance education. *The American Journal of Distance Education, 16* (2), 65-81.

Kirkpatrick, D. C., Duck, S. W. (2004). Handbook of interpersonal communication. *Journal of Social & Personal Relationships, 21* (3), 414-415.

Knight, W. E. (1994). Influences on the academic, career, and personal gains and satisfaction of community college students. Paper presented at the 34th Annual Forum of the Association for Institutional research, May 29- June 1, New Orleans, LA. ERIC ED 3736544.

Knowles, M. S. (1970). The modern principle of adult education: Andragogy versus pedagogy. New York: Cambridge Books.

Koehler, M. J., Mishra, P., Hershey, K., Peruski, L. (2004). With a little help From Your students: A new model for faculty development and online course design. *Journal of Technology and Teacher Education, 12* (1), 25-55.

Kossinets, G., Watts, D. J. (2006). Empirical analysis of an evolving social network. *Science, 311* (5757), 88-90.

Kozoll, C. E. (1982). Time management for educators. Bloomington, Indiana: Phi Delta Kappa Educational Foundation.

Kriesi, H., Koopmans, R., Duyvendak, J. W., and Giugni, M. G. (1992). New social

movements and political opportunities in western Europe. *European Journal of Political Research, 22,* 219-244.

Küppers, G., Lenhard, J. (2005). Validation of simulation: Patterns in the social and natural sciences. *Journal of Artificial Societies and Social Simulation, 8* (4), 1-8.

Landis, J. R., Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33,* 159- 174.

LaBrecque, D. (1998). The physics of learning: Do students obey the laws of physics? Retrieved April 5, 2006 from http://icn2.umeche.maine.edu/instruments/PHYSLRNR.html.

Lao, T., Gonzales, C. (2005). Understanding online learning through a qualitative description of professors and students' experiences. *Journal of Technology and Teacher Education, 13* (3) 459-474.

Levin, S. R., Waddoups, G. L., Levin, J., and Buell, J. (2001). Highly interactive and effective online learning environments for teacher professional development. *International Journal of Educational Technology, 2* (2). Retrieved April 5, 2006 from http://www.ao.uiuc.edu/ijet/v2n2/slevin/index.html.

Lewis, P. J. (2003). Quantum mechanics and ordinary language: The fuzzy link. *Philosophy of Science, 70* (5), 1437-1446.

Littlejohn, S. W. (1996). Theories of human communication. 5th. ed. Belmont, California: Wadsworth.

Lockhorst, D., Admiraal, W., Pilot, A., Veen, W. (2003). Analysis of electronic communication using 5 different perspectives. Paper presented at ORD 2003 (in Heerlen).

Long, P. N. (1993). A study of underprepared students at one community college: Assessing the impact of student and institutional input, environmental, and output variables on student success. Paper presented at the 18th Annual Meeting of the Association for the Study of Higher Education, Nov 4 - 10, Pittsburg, PA. ERIC ED 365177.

Lucas, J. R. (1973). A treatise on time and space. London: Methuen.

Martinez, R. (2004). Online education: Designing for the future in appraiser education. *Appraisal Journal, 72* (3), 266-273.

Marra, R. M., Moore, J. L., Klimczak, A. K. (2004). Content analysis of online discussion forums: a comparative analysis of protocols. *Educational Technology Research Development, 52,* 23–40.

Maxwell, S. E., Camp, C. J., Arvey, R. D. (1981). Measures of strength of association: A comparative examination. *Journal of Applied Psychology, 66,* 525-534.

McComb, M. (1993). Augmenting a group discussion course with computer-mediated communication in a small college setting. Interpersonal Computing and Technology: An Electronic Journal for the 21st Century, Washington, DC: Center for Teaching and Technology, Academic Computer Center Georgetown University. Retrieved April 5, 2006 from http://www.helsinki.fi/science/optek/1993/n3/mccomb.txt.

Merriam, S. B. (2001). The new update on adult learning theory. San Francisco: Jossey-Bass.

Merriam, S. B., Caffarella, R. S. (1999). Learning in adulthood (Second ed.). San Francisco: Jossey-Bass.

Merriam-Webster's collegiate dictionary (10th ed.). (1993). Springfield, MA: Merriam Webster. Retrieved April 5, 2006 from http://dictionary.reference.com.

Meyer, K. A. (2004). Evaluating online discussions: Four different frames of analysis. *Journal of Asynchronous Learning Networks, 8* (2), 101-114.

Meyer, K. A. (2003). Face-to-face versus threaded discussions: The role of time and higher-order thinking. *Journal of Asynchronous Learning Networks, 7* (3), 1-11.

Michael, Y. L., Colditz, G. A., Coakley, E., Kawachi, I. (1999). Health behaviors, social networks, and healthy aging: cross-sectional evidence from the Nurses' Health Study. *Quality of Life Research, 8* (8), 711-722.

Miller, J. H., Butts, C. T., & Rode, D. C. (2002). Communication and cooperation. *Journal of Economic Behavior and Organization, 47,* 179-195.

Moore, M. G., Anderson, W. G. (2003). Handbook of distance education. Mahwah, NJ: Lawrence Erlbaum Associates

Moreno, J. L. (1937). Sociometry in relation to other social sciences. *Sociometry, 1/2,* 206-219.

Morgan, M. (2000). Getting Beyond the Chat: Encouraging and Managing Online Discussions. Retrieved April 5, 2006 from http://cal.bemidjistate.edu/english/morgan/onlinediscussion/.

Muller, D., Judd, C. M., Yzerbyt, V. Y. (2005). When moderation is mediated and mediation is moderated. *Journal of Personality and Social Psychology, 89,* 852-863.

Navarro, P., Shoemaker, J. (2000). Performance and perceptions of distance learners in cyberspace. *The American Journal of Distance Education, 14* (2), 15-35.

Newton, I. (1679). Philosophiae naturalis principia mathematica.

Noel-Levitz. (2005). The 2005 National Adult Learners Satisfaction-Priorities Report. Retrieved April 5, 2006 from http://www.noellevitz.com/Papers+and+Research/Research/ResearchLibrary/

Noether, E. (1918). Invariante varlationsprobleme. *Math-phys. Klasse,* 235-257.

Northam, S. (2005). Tips for time management with online learning. *Online Journal of Nursing Informatics, 9* (3), 1-6.

Oblinger, D. G., Hawkins, B. L. (2006). The myth about online course development. *Educause Review, 41* (1), 14-15.

Palloff, R., Pratt, K. (2001). Lessons from the cyberspace classroom: The realities of online teaching. San Francisco: Jossey-Bass.

Pascarella, E. T., Terenzini, P. T. (1991). How college affects students: Findings and insights from twenty years of research. San Francisco: Jossey Bass.

Petronio, S., Alberts, K. J., Hecht, L. M., Buley, J. (1993). Contemporary Perspective on Interpersonal Communication. Madison, Wisconsin: WCB Brown & Benchmark Publications.

Picciano, A. G. (2002). Beyond student perceptions: Issues of interaction, presence and performance in an online course. *Journal of Asynchronous Learning Networks, 6* (1), 21-40

Plaud, J. J., Gaither, G. A. (1996). Behavioral momentum. *Behavior Modification, 20* (2), 183-201.

Podolinsky, S. (2004). Socialism and the unity of physical forces. *Organization & Environment, 17* (1), 61-75.

Poppel, E. (1978). 'Time Perception', in R.H.H.W. Leibowitz & H.-L. Teuber (Eds.) Handbook of Sensory Physiology. Vol. VIII: Perception. Berlin: Springer.

Porter, S. R., Whitcomb, M. E., Weitzer, W. H. (2004). Multiple surveys of students and survey fatigue. *New Directions for Institutional Research, 121,* 63-73.

Price, V., Nir, L., Cappella, J. (2006). Normative and informational influences in online political discussions. *Communication Theory, 16* (1), 47-74.

Rafaeli, S. (1988). Interactivity: From new media to communication. In R. P. Hawkins, J. M. Wiemann, S. Pingree (Eds.), Advancing communication science: Merging mass and interpersonal processes (pp. 110-134). Thousand Oaks, California: Sage.

Rakich, J. S., Pittinger, L. A. (1999). Characteristics and motivational factors of adult learners. *Education & Society, 17* (2), 33-42.

Reio, T. G. Jr., Crim, S. J. (2006). The emergence of social presence as an overlooked factor in asynchronous online learning. Online Submission Paper presented at the Academy of Human Resource Development International Conference (AHRD) (Columbus, OH, Feb 22-26, 2006), 964-971, (Symp. 46-1).

Roblyer, M. D., Wiencke, W. R. (2003). Design and use of a rubric to assess and encourage interactive qualities in distance courses. *American Journal of Distance Education, 17* (2), 77-98.

Rojo, A. (2005). Halilton's principle: Why is the integrated difference of the kinetic and potential energy minimized? *American Journal of Physics, 73* (9), 831-836.

Roszkowski, M. J., Ricci, R. (2005). Measurement of importance in a student satisfaction

questionnaire: Comparison of the direct and indirect methods for establishing attribute importance. *Journal of College Student Retention Research Theory and Practice, 6* (3), 251-271.

Rummel, R. J. (1970). Applied factor analysis. Evanston: Northwestern University Press.

Ryan, M., Carlton, K. H., & Ali, N. S. (1998). Evaluation of traditional classroom teaching methods versus course delivery via the World Wide Web. *Journal of Nursing Education, 38* (6), 272-277.

Sawyer, S., Southwick, R. (2002). Temporal issues in information and communication technology-enabled organizational change: Evidence from an enterprise systems implementation. *The Information Society, 18,* 263-280.

Schott, J. R. (1996). Matrix Analysis for Statistics. New York: Wiley-Interscience.

Schunk, D. H., Zimmerman, B. J. (1997). Social origins of self-regulatory competence. *Educational Psychology, 32,* 195–208.

Shea, P., Frederickson, E., Pickett, A. (2000). Student satisfaction and perceived learning in Internet-based higher education. *World Conference on Educational Multimedia, Hypermedia and Telecommunications, 1,* 1067-1072.

Shedletsky, L. J., Aitken, J. E. (2001). The paradoxes of online academic work. *Communication Education, 50* (3), 206-217.

Shevlin, M., Miles, J. N. V., Davies, M. N. O., Walker, S. (2000). Coefficient alpha: a useful indicator of reliability? *Personality and Individual Differences,* 28, 229-237.

Shmotkin, D., Eyal, N. (2003). Psychological time in later life: Implications for counseling. *Journal of Counseling & Development, 81* (3), 259-267.

Simons, J., Vansteenkiste, M., Lens, W., Lacante, M. (2004). Placing motivation and future time perspective theory in a temporal perspective. *Educational Psychology Review, 16* (2), 121-128.

Sitek, A., Gullberg, G. T., Huesman, R. H. (2002). Correction for ambiguous solutions in factor analysis using a penalized least squares objective. *IEEE Trans Med Imaging, 21* (3), 216-225.

Smith, G. G., Ferguson, D., Caris, M. (2001). Online vs. face-to-face. *T H E Journal, 28* (9), 18-24.

Soon, K. H., Sook, K. I., Jung, C. W., Im, K. M. (2000). The effects of Internet-based distance learning in nursing. *Computers in Nursing, 18* (1), 19-25.

Sorli, A. (2004). Physical Time and Psychological Time. *Frontier Perspectives, 13* (1), 6-7.

Stacey, E., Smith, P. J., Barty, K. (2004). Adult learners in the workplace: Online learning and communities of practice. *Distance Education, 25* (1), 107-123.

Straus, M. A., Baron, L. (1990). The Strength of weak Indicators: A response to Gilles, Brown, Geletta, and Dalecki. *Sociological Quarterly, 31,* 619–624.

Sundar, S. (2004). Theorizing interactivity's effects. *Information Society, 20* (5), 385-389.

Swan, K. (2002). Building learning communities in online courses: The importance of interaction. *Education, Communication and Information, 2* (1), 23-49.

Swan, K. (2001). Virtual interaction: Design factors affecting student satisfaction and perceived learning in asynchronous online courses. *Distance Education, 22* (2), 306-331.

Szirony, T. A., Telljohann, S. K., Price, J. H., Wolfe, E. (2002). Survey return rates using a covering letter signed by a graduate student or faculty member. *Psychological Reports, 91* (3), 1174-1176.

Taylor, H. (1970). Balance in small groups. Chapter 2, pp. 11-49. New York: Von Nostrand Reinhold Company.

The Sloan Consortium. (2004). Online learning, entering the mainstream: The quality and extent of online education in the United States, 2003 and 2004. Retrieved April 5, 2006 from http://www.sloan-c.org/resources/survey.asp.

Thompson, L., Ku, H-Y. (2005). Chinese graduate students' experiences and attitudes toward online learning. *Educational Media International, 42* (1), 33-47.

Thompson, L. F., Coovert, M. D. (2003). Teamwork online: The effects of computer conferencing on perceived confusion, satisfaction and postdiscussion accuracy. *Group Dynamics: Theory, Research and Practice, 7* (2), 135-151.

Thurmond, V. A. (2003). Examination of interaction variables as predictors of students' satisfaction and willingness to enroll in future web-based courses while controlling for student characteristics. Doctoral dissertation.

Tien, J. M., Burnes, J. P. (2002). On the perception of time: Experiential impact. *IEEE Transactions on Systems, Man & Cybernetics: Part A, 32* (6), 768-775.

Tiene, D. (2000). Online discussions: A survey of advantages and disadvantages compared to face-to-face discussions. *Journal of Educational Multimedia and Hypermedia, 9* (4), 371-384.

Tonfoni, G. (1996). Communication patterns and textual forms. Great Britain: Intellect Books.

Tough, A. (1971). The adult's learning projects: A fresh approach to theory and practice in adult learning. Toronto: The Ontario Institute for Studies in Education.

Tough, A. (1967). Learning without a teacher: A study of tasks and assistance during adult self-teaching projects. Toronto: The Ontario Institute for Studies in Education.

Tu, C-H., Corry, M. (2003). Designs, management tactics and strategies in asynchronous learning discussions. *Quarterly Review of Distance Education, 4* (3), 303-315.

Vamosi, A. R., Pierce, B. G., Slotkin, M H. (2004). Distance learning in an accounting principles course - Student satisfaction and perceptions of efficacy. *Journal of Education for Business, 79* (6), 360-366.

von Mayer, J. R. (1842). Remarks on the forces of inorganic nature. *Annalen der Chemie und Pharmacie, 43,* 233.

Vrasidas, C., McIsaac, M. S. (1999). Factors influencing interaction in an online course. *The American Journal of Distance Education, 13* (3), 22-36.

Walther, J. B. (1996). Computer-mediated communication: Impersonal, interpersonal and hyperpersonal interaction. *Communication Research, 23* (1), 3-43.

Walther, J. B., Burgoon, J. K. (1992). Relational communication in computer-mediated interaction. *Human Communication Research, 19* (1), 50-88.

Wang, Y-S. (2003). Assessment of learner satisfaction with asynchronous electronic learning systems. *Information & Management, 41* (1), 75-86.

Warren, L., Holloman, H. (2005). On-line instruction: Are the outcomes the same? *Journal of Instructional Psychology, 32* (2), 148-151.

Wasserman, S., Faust, K. (1994). Social network analysis: Methods and applications.

Cambridge: Cambridge University Press.

Weng, L-J. (2004). Impact of the number of response categories and anchor labels on coefficient alpha and test-retest reliability. *Educational & Psychological Measurement, 64* (6), 986-972.

Wenger, E., McDermott, R., Snyder, W. (2002). Cultivating Communities of Practice: A Guide to Managing Knowledge. Cambridge, MA: Harvard Business School Press.

Wiers-Jenssen, J., Stensaker, B. & Grøgaard, J. B. (2002). Student Satisfaction: towards an empirical deconstruction of the concept. *Quality in Higher Education, 8* (2), 1-14.

Wiesenberg, F., Hutton, S. (1996). Teaching a graduate program using computer-mediated conferencing software: Distance education futures. *Journal of Distance Education, 11* (1), 83-100.

White, D. R., Owen-Smith, J., Moody, J., Powell, W. W. (2004). Networks, fields and organizations. *Computational and Mathematical Organization Theory, 10,* 95-117.

White, K. W., Weight, B. H. (2000). The online teaching guide: A handbook of attitudes, strategies, and techniques for the virtual classroom. Boston: Allyn and Bacon.

Whitworth, M. (1998). Inspector heat inspected: The Secret Agent and the meanings of entropy. *Review of English Studies, 49* (193), 40-59.

Wiltshire, H. (1956). The great tradition in university adult education. Adult Education, XXIX: 2.

Wiers-Jenssen, J., Stensaker, B. & Grøgaard, J. B. (2002). Student Satisfaction: towards

an empirical deconstruction of the concept. *Quality in Higher Education, 8* (2), 1-14.

Winiecki, D. (1999). Keeping the Thread: Adapting Conversational Practice to Help Distance Students and Instructors Manage Discussions in an Asynchronous Learning Network, *DEOSNEWS, 9* (2). Retrieved April 5, 2006 from http://www.ed.psu.edu/ACSDE/.

Wolfson, R., Pasachoff, J. M. (1995). Physics with modern physics. New York: Harper Collins College Publishers.

Wright, S. (2006). Reflections on the disciplinary gulf between the natural and social sciences. *Community Genetics, 9,* 161-169.

Wright, V. H., Marsh, G. E., Miller, M. T. (2000). A critical comparison of graduate student satisfaction in asynchronous and synchronous course instruction. *Planning and Changing, 31* (1-2), 107-118.

Zembylas, M. Vrasidas, V. (2005).Globalization, information and communication technologies, and the prospect of a global village - Promises of inclusion or electronic colonization. *Journal of Curriculum Studies, 37* (1), 65-83.

Zemljič, B, Hlebec, V. (2005). Reliability measures of centrality and prominence. *Social Networks, 27,* 73-88.

Zhang, S., Fulford, C. P. (1994). Are interaction time and psychological interactivity the same thing In The distance learning television classroom? *Educational Technology, 34* (6), 58-64.

Zirkin, B. G., Sumler, D. E. (1995). Interactive or non-interactive? That is the question!!! An annotated bibliography. *Journal of Distance Education, 10* (1), 95-112.

Appendix A

Descriptive Statistics for Leaner Satisfaction Survey

Table A4-1

Percentages of Demographic Items (Max N=102)

#	Item	f	%
1	**Gender**	93	100
	Female	82	88
	Male	11	12
2	**Status**	83	100
	Part-time	35	42
	Full-time	48	58
3	**Race**	39	100
	White	35	90
	Black	4	10
4	**Age Range**	53	100
	18-29	27	51
	30-39	12	23
	40-49	9	17
	50-59	5	9
5	**Number of Online Courses Previously Taken**	85	100
	0 - 4	38	45
	5 - 9	40	47
	10 or more	7	8

Table A4-2A

Descriptive Statistics for Section II-A of Learner Satisfaction Survey

#	Item	Mean (SD)
1	My interest in online learning before this course	5.4 (1.1)
2	My interest in this particular course topic	5.3 (1.3)
3	My overall satisfaction with online courses before this one	5.2 (1.3)
4	My personal success with online courses before this one	5.7 (1.2)
5	My ability to be responsible for managing my time	5.7 (1.1)
Average of Items 1 to 5		5.4 (0.9)

#	Min	Max	Range	Peak Symmetry		Peak Sharpness		Mean (SD)
				Skew	Error	Kurtosis	Error	
1	3	7	4	-0.508	0.240	-0.403	0.476	5.4 (1.1)
2	1	7	6	-1.327	0.240	1.828	0.476	5.3 (1.3)
3	3	7	4	-0.138	0.240	-1.024	0.476	5.2 (1.3)
4	4	7	3	-0.210	0.240	-1.474	0.476	5.7 (1.2)
5	4	7	3	-0.339	0.240	-1.232	0.476	5.7 (1.1)
Av	3.4	7.0	3.6	-0.404	0.240	-0.395	0.476	5.4 (0.9)

Table A4-2B

Descriptive Statistics for Section II-B of Learner Satisfaction Survey

#	Item	Mean (SD)
6	My time available to participate in this entire course	3.4 (0.9)
7	My time available to participate in the discussion boards	3.4 (0.8)
8	My personal energy to participate in course	3.8 (0.8)
9	My personal energy to participate in the discussion boards	3.7 (0.7)
10	My personal motivation to participate in course	4.0 (0.7)
11	My personal motivation to participate in the discussion boards	3.9 (0.6)
12	The amount of homework/projects/exams required	4.1 (0.5)
13	The encouragement and support from my teacher and classmates	4.1 (0.7)
Average of Items 6 to 13		3.8 (0.5)

				Peak Symmetry		Peak Sharpness		
#	Min	Max	Range	Skew	Error	Kurtosis	Error	Mean (SD)
6	2	5	3	-0.140	0.239	-0.971	0.474	3.4 (0.9)
7	2	5	3	0.011	0.239	0.532	0.474	3.4 (0.8)
8	2	5	3	-0.493	0.239	0.164	0.474	3.8 (0.8)
9	2	5	3	-0.666	0.239	0.660	0.474	3.7 (0.7)
10	2	5	3	-0.716	0.239	0.971	0.474	4.0 (0.7)
11	2	5	3	-0.880	0.241	2.058	0.478	3.9 (0.6)
12	3	5	2	0.148	0.241	0.902	0.478	4.1 (0.5)
13	2	5	3	-0.816	0.243	1.402	0.481	4.1 (0.7)
Av	2.8	5	2.2	-0.046	0.239	-0.355	0.474	3.8 (0.5)

Table A4-2C

Descriptive Statistics for Section II-C of Learner Satisfaction Survey

#	Item	Mean (SD)
14	My job _____ with my ability to get my coursework done	3.8 (1.6)
15	My social life _____ with my ability to get my coursework done	3.9 (1.0)
16	My other courses _____ with my ability to get my coursework done	3.2 (1.1)
17	My computer skills _____ with my ability to get my coursework done	5.2 (1.3)
18	My writing skills _____ with my ability to get my coursework done	5.0 (1.1)
19	My communication skills _____ with my ability to get my coursework done	5.2 (1.1)
Average of Items 14 to 19		4.4 (0.6)

#	Min	Max	Range	Peak Symmetry		Peak Sharpness		Mean (SD)
				Skew	Error	Kurtosis	Error	
14	1	7	6	-0.102	0.243	-0.651	0.481	3.8 (1.6)
15	1	7	6	-0.237	0.253	1.325	0.500	3.9 (1.0)
16	1	6	5	-0.474	0.250	-0.347	0.495	3.2 (1.1)
17	2	7	5	-0.124	0.245	-0.767	0.485	5.2 (1.3)
18	1	7	6	-0.176	0.245	0.506	0.485	5.0 (1.1)
19	2	7	6	-0.082	0.245	-0.598	0.485	5.2 (1.1)
Av	2.0	5.7	3.7	-0.643	0.243	2.289	0.481	4.4 (0.6)

Table A4-3

Descriptive Statistics for Learner Satisfaction Items (N_{MAX} = 102)

#	I was satisfied that . . .	Mean (SD)	
		Mid-Semester	End of Semester
1a	There was **enough** time to respond to other people's messages on the discussion boards.	3.7 (1.8)	3.9 (1.7)
1b	There was **enough** time to think of how to start a discussion on the discussion boards.	3.9 (1.7)	4.1 (1.6)
2a	I was able to post **enough** messages for each forum.	3.7 (1.7)	3.8 (1.7)
2b	My peers were able to post **enough** messages for each forum.	3.9 (1.8)	4.0 (1.8)
2c	My instructor was able to post **enough** messages for each forum.	3.8 (2.0)	3.8 (2.0)
3a	I was able to post messages **regularly.**	4.4 (1.6)	4.5 (1.6)
3b	My peers posted messages **regularly.**	4.5 (1.6)	4.6 (1.6)
3c	My instructor posted messages **regularly.**	4.3 (1.8)	4.4 (1.8)
4a	There were factors in my life that kept me from participating **enough** on the discussion boards.	3.9 (1.7)	3.9 (1.7)
4b	There were factors in my life that kept me from **consistently** (regularly) participating on the discussion boards.	4.1 (1.6)	4.2 (1.7)
5a	The discussion board forums held my interest **adequately.**	4.2 (1.8)	4.2 (1.9)
5b	The discussion board forums held my interest **consistently.**	4.6 (1.3)	4.7 (1.3)
6a	The pace of the discussions was **adequate** over the semester.	4.1 (1.9)	4.1 (1.9)
6b	The pace of the discussions was **consistent** over the semester.	4.5 (1.5)	4.6 (1.5)
7a	The length of my postings was **long enough.**	3.8 (1.9)	3.9 (1.9)
7b	The length of my postings was **consistent.**	4.4 (1.4)	4.5 (1.4)
7c	The length of my peer's postings was **long enough.**	4.2 (2.0)	4.2 (2.0)
7d	The length of my peer's postings was **consistent.**	4.5 (1.5)	4.6 (1.4)
8a	The quality of my postings was **good.**	3.7 (1.8)	3.9 (1.8)
8b	The quality of my postings was **consistent.**	3.9 (1.3)	3.9 (1.2)
8c	The quality of my peer's postings was **good.**	3.9 (1.8)	4.1 (1.9)
8d	The quality of my peer's postings was **consistent.**	4.0 (1.5)	4.2 (1.4)
9a	Using the discussion boards was a **good** use of my time.	4.1 (1.9)	4.1 (2.0)
9b	Using the discussion boards was an **efficient** use of my time.	4.0 (1.9)	4.0 (1.9)
10	Overall, I am **satisfied** with my experience with the discussion boards.	4.0 (1.9)	4.1 (2.0)
Average of Items 1a to 9b		4.1 (1.3)	4.2 (1.3)

Table A4-3 cont'd

#	Min	Max	Range	Peak Symmetry		Peak Sharpness		End of Semester Mean (SD)
				Skew	Error	Kurtosis	Error	
1a	1	7	6	0.229	0.244	-0.798	0.483	3.9 (1.7)
1b	1	7	6	0.041	0.244	-0.632	0.483	4.1 (1.6)
2a	1	7	6	0.072	0.240	-1.038	0.476	3.8 (1.7)
2b	1	7	6	-0.105	0.240	-1.074	0.476	4.0 (1.8)
2c	1	7	6	0.048	0.240	-1.297	0.476	3.8 (2.0)
3a	1	7	6	-0.577	0.240	-0.392	0.476	4.5 (1.6)
3b	1	7	6	-0.588	0.240	-0.351	0.476	4.6 (1.6)
3c	1	7	6	-0.578	0.240	-0.756	0.476	4.4 (1.8)
4a	1	7	6	0.153	0.244	-0.617	0.483	3.9 (1.7)
4b	1	7	6	0.222	0.244	-0.547	0.483	4.2 (1.7)
5a	1	7	6	-0.146	0.240	-1.170	0.476	4.2 (1.9)
5b	1	7	6	-0.474	0.240	-0.414	0.476	4.7 (1.3)
6a	1	7	6	-0.041	0.240	-1.154	0.476	4.1 (1.9)
6b	1	7	6	-0.561	0.240	-0.009	0.476	4.6 (1.5)
7a	1	7	6	0.266	0.240	-1.165	0.476	3.9 (1.9)
7b	1	7	6	-0.464	0.240	0.171	0.476	4.5 (1.4)
7c	1	7	6	0.147	0.240	-1.260	0.476	4.2 (2.0)
7d	1	7	6	-0.598	0.240	0.104	0.476	4.6 (1.4)
8a	1	7	6	0.390	0.240	-1.125	0.476	3.9 (1.8)
8b	1	7	6	-0.106	0.240	-0.096	0.476	3.9 (1.2)
8c	1	7	6	0.148	0.240	-1.170	0.476	4.1 (1.9)
8d	1	7	6	0.126	0.240	-0.163	0.476	4.2 (1.4)
9a	1	7	6	0.029	0.240	-1.093	0.476	4.1 (2.0)
9b	1	7	6	0.106	0.240	-1.020	0.476	4.0 (1.9)
10	1	7	6	0.014	0.243	-1.102	0.481	4.1 (2.0)
Av	1.7	6.7	5.0	-0.049	0.240	-1.034	0.476	4.2 (1.3)

Table A4-4

Descriptive Statistics for Leaner Satisfaction and Momentum

		N	Mean (SD)	
			Mid-Semester	End of Semester
Learner Satisfaction	Overall	51	4.39 (1.94)	4.49 (1.94)
	Average	52	4.39 (1.27)	4.43 (1.29)
Learner Momentum	Degree	51	3.41 (5.53)	3.18 (4.23)
	Closeness	51	41.21 (57.42)	44.21 (49.75)
	Betweenness	51	166.4 (287.5)	98.0 (129.0)

Appendix B

IRB Forms and Project Abstract

September 1, 2005

Chris Buth-Furness
IRB Administrator
Institutional Review Board for the Protection of Human Subjects
The Graduate School
University of Wisconsin - Milwaukee
PO Box 340
Milwaukee, WI 53201

Dear Ms. Buth-Furness:

Attached to this letter is the Human Subjects Protocol for the study **Examination of Asynchronous Communication Patterns in Online Courses and Their Impact on Learner Satisfaction.** I have included the IRB forms, project abstract, survey instrument, and the survey cover letter (which includes the informed consent).

If you have any questions, please call me at (262) 377-5317

or e-mail me at BobTreat@uwm.edu

Thank you for your time and effort!

Bob Treat

For Office Use Only	DATE STAMP
Protocol No. **Subcommittee**	☐ Logged ☐ Recorded on Agenda for:

University of Wisconsin-Milwaukee
Institutional Review Board

Human Subjects Review
Protocol Coversheet

Questions?? Contact:
Chris Buth-Furness
Human Protections
Administrator
Mitchell Hall, Room 206
(414) 229-3173 / Phone
(414) 229-5000 / FAX

☒ Submitting NEW PROTOCOL ☐ MODIFYING PROTOCOL
☐ FULFILLING CONDITIONS ☐ ANNUAL PROGRESS REPORT

I. Information About the Protocol

PROJECT TITLE: (Print or Type) Examination of Asynchronous Communication Patterns in Online Courses and Their Impact on Adult Learner Satisfaction

A. Is this project ***EXTERNALLY FUNDED***? Check: ☐ **YES** ☒ **NO**
Funding Source:
Should we notify your funding source when you have IRB approval?
Check: ☐ **YES** ☐ **NO**
Address of funding source to be notified:

UW-Milwaukee *Proposal No.* (if any)
Total Project Period: (Start date/End date) May 2005/December 2005

B. Is this project ***INTERNALLY FUNDED***? Check: ☐ **YES** ☒ **NO**
Funding Source:

C. Is this project ***THESIS OR DISSERTATION*** research?
Check: ☒ **YES** ☐ **NO**

D. Does this protocol involve ***PAYMENT TO RESEARCH SUBJECTS***?
Check: ☐ **YES** ☒ **NO**
If **YES** check the appropriate confidentiality level:
☐ **LEVEL 1** ☐ **LEVEL 1A** ☐ **LEVEL 2** ☐ **LEVEL 3**

II. Information About the Investigator(s)

Please fill out the following contact information completely.
Missing information will result in communication delays on the status of your protocol.
(This page may be copied if more then 2 investigators are working on the same protocol.)

PRINCIPAL INVESTIGATOR	CO-INVESTIGATOR
Last Name: Treat	**Last Name:**
First Name: Robert	**First Name:**
Title/Position: Doctoral Dissertator	**Title/Position:**
Dept.: Admin Leadership **Bldg./Room:** Enderis	**Dept.:** **Bldg./Room:**
Campus Phone: **Home Phone:** 262 377-5317	**Campus Phone:** **Home Phone:**
Home Address (required for students):	**Home Address (required for students):**
City: Grafton **State:** WI **Zip:** 53024	**City:** **State:** **Zip:**
Email: bobtreat@uwm.edu	**Email:**

The *principal investigator (PI)* is the primary contact person for each protocol. Please indicate the following:

How does the PI wish to be notified of actions taken on the protocol?	☒ **E-mail**	☐ **Regular Mail**
Which mailing address does the PI prefer?	☒ **Home**	☐ **Campus Off**
If procedural or substantive questions arise during the review of the protocol, would the PI like the reviewer to call or email her/him and discuss these matters?	☒ **YES**	☐ **NO**
Has the PI completed the UWM Human Subjects Training Module?	☒ **YES**	☐ **NO**
Has the PI completed any other "responsible conduct of research" course work or training?	☒ **YES**	☐ **NO**

III. Review Status

I am requesting the following type of review:

- ☐ **EXEMPT, Category:**
- ☒ **MINIMAL RISK**
- ☐ **Full IRB Review, at a convened Board Meeting**
- ☒ **Expedited Review, Category: 7**
- ☐ **RISK OR DECEPTION**
- ☐ **CONTINUING REVIEW (Annual Progress Report)** *Go to Section V.*

IV. Special Subject Populations

This protocol calls for the recruitment of the following special subject populations:
(check ALL that apply)

☐ **Minors/Children** ☐ **Fetuses** ☐ **Pregnant Women**
☐ **Prisoners** ☐ **Illegal Behavior** ☐ **Cognitively Impaired**
☐ **Mentally Ill** ☐ **Test subjects for new drugs or clinical devices**

V. Continuing Review –

Complete this section ONLY if requesting continuing review (i.e., annual review/renewal) of a protocol OR reporting the status of a protocol.

RISK CATEGORY: ☐ Exempt ☐ Minimal Risk ☐ Risk / Deception

STATUS OF PROJECT: *(check one)*

☐ Ongoing -- Estimated completion date:
☐ Ongoing -- Not enrolling new subjects; data analysis and writing
☐ Completed
☐ Never started / No need to renew ☐ Check here if not funded
☐ Incomplete -- Please explain:
☐ Pending -- Not yet started

Have you made any changes to your protocol in the past year? Check: ☐ **YES** ☐ **NO**
If **YES**, *highlight the changes on a complete copy of your protocol and attach that complete protocol copy, including the informed consent,* to this coversheet and return it to the IRB office.
REPORT any change in title of protocol or name of investigator(s) here:

STATUS REPORT: *On a separate page*, summarize the results you have achieved thus far in your study. Reiterate each question and provide a complete answer. Include ALL of the following topics in your discussion. ***Protocols requiring an annual continuing review will not be reviewed without an accompanying status report.***

A. A description of the following:
1. The total number of subjects enrolled in the research since IRB approval.
2. Have there been any non-medical problems or complications that have affected the subjects or any other persons involved in the research since the last IRB review? If "yes," please explain.
3. Did any subject suffer an unanticipated adverse event that was reported to the IRB since your last review? If "yes," please explain.
4. Was there any unusual increase in the frequency of serious but expected adverse events? If "yes," please explain.
5. Were there any serious, external, adverse event reports related to this study submitted to the IRB by you or any other person?
6. Was any subject withdrawn by you from the study because of medical problems or complications? If "yes," please explain.
7. Did any subject voluntarily withdraw from the study? If "yes," please explain.
8. Did any problems occur related to obtaining and documenting informed consents? If "yes," please explain.
9. Has anything occurred since the last IRB review that may have altered the risk / benefit relationship? If "yes," please explain.

B. A summary of any recent literature, findings, or relevant information, especially information about risks associated with the research.

C. A COMPLETE copy of the ***CURRENT PROTOCOL AND INFORMED CONSENT FORM(s)*** utilized in your research. THIS IS VERY IMPORTANT IF YOU HAVE MADE A NUMBER OF MODIFICATIONS TO THE PROTOCOL.

VI. Principal Investigator Assurance:

I understand that all human subject research conducted at the University of Wisconsin-Milwaukee is subject to the requirements of the federal regulations contained in Title 45 Part 46 of the Code of Federal Regulations, The Belmont Report, and the UWM Multiple Project Assurance, including the responsibility to obtain Informed Consent from study subjects, and I will comply with those requirements.

Principal Investigator – PRINT NAME	**Faculty Advisor – PRINT NAME**
Robert W. Treat	**Dr. Barbara J. Daley**
Principal Investigator – SIGNATURE / DATE	**Faculty Advisor – SIGNATURE / DATE**

If this protocol has been reviewed decentrally, that reviewer must sign and date below.

Decentral Reviewer (Signature)	DATE of Review

Examination of Asynchronous Volumetric and Frequency Communication Patterns in Online Courses and Their Impact on Adult Learner Satisfaction

Project Qualifies as Minimal Risk

This project qualifies as minimal risk expedited category 7 since the identities of any and all participants involved in the study will be replaced with generic identifier values in the database once it has been constructed. Access to the database is restricted to the researcher only. All data that contains any learner identity will be destroyed: (1) paper products through shredding and combustion, and (2) electronic files through electronic scrambling and erasure from hard drive. Only aggregate values will be reported in the dissertation and any subsequent publications so as to protect the data of all participants.

Project Summary

Published research about the association of asynchronous communication and learner satisfaction is scarce. One way to understand the nature of asynchronous communication is to investigate the patterns of asynchronous communication, which can be done conveniently through online courses. The growth of the World Wide Web in the last decade has increased the opportunities to explore asynchronous communication through electronic tools such as e-mail and discussion boards. Although e-mail is more widely used than discussion boards for communication, logistical hurdles such as access and social issues such as privacy make discussion boards an easier medium within which to study asynchronous communication.

Social network analysis from sociology and kinetic and thermodynamic parameters from physics will be used to describe and analyze the spatial and temporal patterns of

communication. This study will use information readily available from discussion boards in academic online classes and learner surveys to examine the association of asynchronous communication patterns and learner satisfaction. This association is important in adult learning, where the limitations in time is a crucial component for many adults, but is alleviated by the flexibility and convenience of online learning.

Data Collection

The following data must be collected in order to complete this study: (1) time of discussion board postings, (2) number of words in each message, (3) name of learner for each posting (only for linking the data initially, this will be removed upon completion of the dataset and it's link to the learner satisfaction survey), (4) position of each discussion board posting with respect to thread and forum, and (5) overall learner satisfaction.

In order to collect this data, the following steps must be taken:

1) Permission to collect data from the department and school in question

2) Approval by five-member dissertation committee

3) Approval by Institutional Review Board (IRB) at the University of Wisconsin - Milwaukee

4) Electronic notification to learners via e-mail and announcement through the educational portal interface for participation in research and security measures taken to maximize protection of learner identity

5) Follow-up response to item 4 two weeks later.

Data Analysis

This project will be a correlational design with learner satisfaction as the outcome (item five in the data collection section). Communication patterns will be the

independent variables and are determined through communication constructs that are mathematically modeled after the physical parameters of momentum, force and energy. The data for the construction of the communication constructs comes directly from the text available on the discussion boards, which includes items one through four listed above in the data collection section.

Data Security

Once the association between learner communication patterns is made with learner satisfaction and all data has been entered into a database, I will substitute a generic identifier for student names. No information will be saved on any personal computer, school server or transportable medium containing student names, course number, department, school, or university name. The electronic file will be saved in a compressed and encrypted form via 256-bit key AES encryption, which provides a high level of cryptographic security. The advanced encryption (FIPS-197 certified) uses the Rijndael cryptographic algorithm which was specified by the National Institute of Standards and Technology (NIST) in Federal Information Processing Standards (FIPS) Publication 197 as the Advanced Encryption Standard (AES).

The electronic file will be saved on a computer with Windows XP and no access to the Internet. The computer requires a username and password for entry. This will provide two layers of electronic security for the file. If the electronic file needs to be destroyed after the study, then it will electronically scrambled using Guttmann pseudorandom data and U.S. Department of Defense 5220-22.M methods.

Any paper products that have student names on it will be destroyed through shredding and combustion immediately after data is entered into the database.

Appendix C

Informed Consent Form

Informed Consent Form

Title: The Examination of Asynchronous Communication Patterns in Online Courses and their Impact on Adult Learner Satisfaction

Description: I understand that I have been asked to participate in this research study that will examine how my communication patterns on the discussion board of this online course will impact my satisfaction with the experience.

Procedures: I understand that I will be asked to complete an electronic survey where the primary focus will be on my satisfaction with the online course that I am now participating in. In particular, the questions will focus mostly (but not entirely) on satisfaction with the written electronic communication that I participated in the discussion board forums of this course. Furthermore, some demographic questions regarding my gender, race, and age will be asked on the survey.

I understand that in order to link the actual communication patterns that are on the discussion board of this course to the learner satisfaction form, I will be asked for my name. However, I will be guaranteed ALL of the following steps will be guaranteed by the researcher to protect my identity:

1) The electronic database file containing the data on communication patterns will be kept on a separate computer from the database file which contains the data from the learner satisfaction survey.

2) Unique, but generic identifiers will be substituted in for all student names, once the two database files have been created. This identifier will allow the researcher to connect the two files together, which will create one integrated file. This integrated file will be kept on a third computer, separate from the original two computers.

3) All three electronic files will be saved in a compressed and encrypted form via 256-bit key AES encryption, which provides a high level of cryptographic security. The advanced encryption (FIPS-197 certified) uses the Rijndael cryptographic algorithm which was specified by the National Institute of Standards and Technology (NIST) in Federal Information Processing Standards (FIPS) Publication 197 as the Advanced Encryption Standard (AES).

4) The electronic files will be saved on a computer with Windows XP and no access to the Internet. The computer requires a username and password for entry. This will provide two layers of electronic security for the file. The electronic files will be destroyed after the study, in which they will be electronically scrambled using Guttmann pseudorandom data and U.S. Department of Defense 5220-22.M methods.

I understand that all participants in this study are students of higher education and at least eighteen years of age.

Risks and Benefits: I understand that even though the researcher will make every effort to protect my identity, there is still the remote possibility that electronic hacking and or criminal theft may put my identity within the possession of someone who does not have my permission to have such information.

I understand that once the study is completed, I will be provided the results of this study, if I choose to review such information. I understand that this study will provide no other direct benefit to me.

I understand that I will not be charged for my participation in this study, nor will I be paid for participating.

Safeguards: I understand that any information about me will be treated in a confidential manner and that the data collected and the results obtained will be used for scientific purposes only. My name and initials will never be used to report any results of the project. I understand that the records and data files related to this research project will be maintained in the researcher's laboratory for a period no longer than three years and that only those personnel directly associated with this project will have access to them.

Freedom to Withdraw: I understand that I may refuse to participate in this study or withdraw at any time without penalty. I understand that I may be withdrawn from this study by the investigators if I do not meet the screening criteria. I understand that, should I withdraw or be withdrawn from the study, any information that I have provided will be destroyed.

Voluntary Consent: This study has been explained to me and my questions have been answered. If I have additional questions I may contact the principal investigator:

Robert Treat
Department of Administrative Leadership
University of Wisconsin-Milwaukee
Milwaukee, WI 53201

I understand that if I have any complaints about my treatment in this study I may call or write:

Chris Buth Furness
Institutional Review Board for the Protection of Human Subjects
Graduate School
University of Wisconsin-Milwaukee
P.O. Box 340
Milwaukee, WI 53201
(414) 229-3173

Although Ms. Buth Furness will ask my name, all complaints are kept in confidence.

I have received an explanation of this study and agree to participate. I understand that my participation in this study is strictly voluntary.

_____ _____

Name Date

This research project has been approved by the University of Wisconsin-Milwaukee Institutional Review Board for the protection of Human Subjects for a one year period.

Appendix D

Learner Satisfaction Survey for Online Discussion Boards

Learner Satisfaction Form for Online Discussion Boards

The items on this learner satisfaction survey will focus on how *adequate* and *consistent (regular)* certain aspects of the discussion boards were during mid-semester and at the end of the course.

I) Background Information:

Name	
Gender	
Race	
Age Range	<18 | 18-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80+
Student Status	(circle one) Part-time Full-time

Number of Online Courses previously taken before this course: _____
Grade expected in this course: _____
How **successful** were you in previous online courses? _____
(1=not successful to 10=very successful)

Please indicate the number of hours per week you spent on:	**Hours/Week**
1) this course overall	
2) the discussion boards in this course	
3) using e-mail with your classmates	
4) using e-mail with your instructor	
5) using e-mail with everyone else but your classmates and instructor	
6) using chat rooms (in and out of class)	
7) using instant messaging (in and out of class)	

II) Items that affected your ability to participate in this course

A) Please rate how each item may have affected your ability to participate in the course on the following seven-point scale. If the item is Not Applicable, please leave it blank.

1=Strongly Negative	2=Moderately Negative	3=Slightly Negative	4=Neutral	5=Slightly Positive	6=Moderately Positive	7=Strongly Positive

Items for Part A	**Rating**
1) My *interest* in online learning before this course had been _____.	
2) My *interest* in this particular course topic had been _____.	
3) My overall *personal satisfaction* with online courses before this one had been _____.	
4) My *personal success* with online courses before this one had been _____.	
5) My ability to be responsible for *managing my time* has been _____.	

B) Please rate how each item may have affected your ability to participate in the course on the following five-point scale. If the item is Not Applicable, please leave it blank.

1=None 2=A Tiny Amount 3=A Small Amount 4=A Moderate Amount 5= A Large Amount

Items for Part B	Rating
6) My ***time*** available to participate in this entire course has been _____.	
7) My ***time*** available to participate in the discussion boards has been _____.	
8) My personal ***energy*** to participate in course has been _____.	
9) My personal ***energy*** to participate in the discussion boards has been _____.	
10) My personal ***motivation*** to participate in course has been _____.	
11) My personal ***motivation*** to participate in the discussion boards has been _____.	
12) The ***amount*** of homework/projects/exams required was _____.	
13) The ***encouragement and support*** from my teacher and classmates was _____.	

C) Please rate how each item may have affected your ability to get your coursework done. If the item is Not Applicable, please leave it blank.

1=Interfered a Lot 2=Interfered Somewhat 3=Interfered a Little 4=Had No Effect 5=Helped a Little 6=Helped Somewhat 7=Helped a Lot

Items for Parts C	Rating
14) My ***job*** _____ with my ability to get my coursework done.	
15) My ***social life*** _____ with my ability to get my coursework done.	
16) My ***other courses*** _____ with my ability to get my coursework done.	
17) My ***computer skills*** _____ with my ability to get my coursework done.	
18) My ***writing skills*** _____ with my ability to get my coursework done.	
19) My ***communication skills*** _____ with my ability to get my coursework done.	

Please list and rate any other items that may have helped or interfered with your ability to get your coursework done:

Items for Parts C	Rating
20)	
21)	
22)	

III) Discussion Board Evaluation

Please rate each item on the following seven-point scale:

1=Strongly Disagree 2=Moderately Disagree 3=Slightly Disagree 4=Neutral 5=Slightly Agree 6=Moderately Agree 7=Strongly Agree

#	I was satisfied that . . .	During Mid-Semester	By the End of the Semester
Ex	This was an interesting way to spend time.	5	6
1a	There was **enough** time to respond to other people's messages on the discussion boards.		
1b	There was **enough** time to think of how to start a discussion on the discussion boards.		
2a	I was able to post **enough** messages for each forum.		
2b	My peers were able to post **enough** messages for each forum.		
2c	My instructor was able to post **enough** messages for each forum.		
3a	I was able to post messages **regularly.**		
3b	My peers posted messages **regularly.**		
3c	My instructor posted messages **regularly.**		
4a	There were factors in my life that kept me from participating **enough** on the discussion boards.		
4b	There were factors in my life that kept me from **consistently** (regularly) participating on the discussion boards.		
5a	The discussion board forums held my interest **adequately.**		
5b	The discussion board forums held my interest **consistently.**		
6a	The pace of the discussions was **adequate** over the semester.		
6b	The pace of the discussions was **consistent** over the semester.		
7a	The length of my postings was **long enough.**		
7b	The length of my postings was **consistent.**		
7c	The length of my peer's postings was **long enough**		
7d	The length of my peer's postings was **consistent.**		
8a	The quality of my postings was **good.**		
8b	The quality of my postings was **consistent.**		
8c	The quality of my peer's postings was **good**		
8d	The quality of my peer's postings was **consistent.**		
9a	Using the discussion boards was a **good** use of my time.		
9b	Using the discussion boards was an **efficient** use of my time.		
10	Overall, I am **satisfied** with my experience with the discussion boards.		
11	I would like to use discussion boards in my next course.		

Curriculum Vitae

Robert W. Treat

Place of Birth

Princeton, New Jersey

Education

Ph.D. (2006) - University of Wisconsin - Milwaukee - Education (Administrative Leadership)

Dissertation Title: Examination of Asynchronous Volumetric and Frequency Communication Patterns in Online Courses and Their Impact on Adult Learner Satisfaction

M.S. (1996) - Marquette University - Bio-analytical Chemistry

Thesis Title: Resonance Raman Studies of Lactoperoxidase and its Catalytic Intermediates

B.S. (1987) - University of Wisconsin - Milwaukee - Chemistry

Teaching and Professional Experience

Medical College of Wisconsin - Psychometrician and Senior Educational Evaluator (Sep 2005 to present)
- Educational Specialist (Aug 1999 to Aug 2005)

- Provided statistical analysis and technical support to on-going research and evaluation projects in medical education.
- Consulted faculty and staff regarding appropriate design and analysis for educational research and evaluation projects.
- Taught faculty principles of educational measurement as part of established faculty development.
- Maintained and secured large inventory of databases of ongoing projects.
- Three publications: *Ambulatory Pediatrics (2004), American Journal of Obstetrics and Gynecology (2002) and Academic Medicine (2000).*

University of Wisconsin - Milwaukee - Instructor and Course Designer (Aug 2002 - May 2004)

- Instructed and designed an interactive hybrid online/resident course in statistics for the department of Educational Psychology using BlackBoard, Macromedia Flash and Dreamweaver.

Marquette University - Instructor and Course Designer (Summers of 1995 - 2001)

- Instructed and designed three courses in organic and general chemistry for the Health Careers Opportunity Program, a federally sponsored program for disadvantaged students who are interested in the healthcare fields of dentistry, physical therapy, or physician assistant studies.
- Worked with Department of Multicultural Affairs, the School of Dentistry and the Department of Physical Therapy.

Marquette University - Laboratory Instructor (Aug 1990 - Aug 2005)

- Instructed undergraduate laboratories in physics, chemistry and arts & sciences.
- Fifteen years experience / corrected over 15,000 physics lab reports.

University of Wisconsin - Milwaukee - Independent Researcher (Jan - May 2002)

- Provided statistical analysis to on-going video game research in project for Department of Mass Communication.

Marion College - Adjunct Professor (Jan 1998 - May 1998)

- Instructed course in general chemistry.
- Supervised laboratory instructor.

Waukesha County Technical College - Instructor (Aug 1997 - Dec 1997)

- Instructed courses in general physics consisting of lecture and lab.

Kaplan Agency - Instructor (Jan 1996 - Aug 1997)

- Instructed development of test-taking skills for college undergraduates taking the Medical College Admissions Test.

Milwaukee Area Technical College - Instructor (Jan 1994 - Dec 1995)

- Instructed courses in general chemistry consisting of lecture and lab.
- Tutored students in math, chemistry and physics.

Marquette University - Graduate Student Researcher (May 1991 - Sept 1996)

- Investigated structure/function relationships of heme proteins through spectroscopic analysis (Raman, UV-VIS, IR) using moderate power ion lasers.
- Isolation and purification of proteins through chromatography
- One publication in *Biochemistry (Sept 1993).*

Peer-Reviewed Publications

- Simpson, D. E., Bragg, D., Biernat, K., **Treat, R.** (2004). Outcomes results from the evaluation of the APA/HRSA Faculty Scholars Program. *Ambulatory Pediatrics, 4* (1 Suppl), 103-112.

- Autry, A. M., Meurer, L. N., Barnabei, V. M., Green, S. S., Johnson-Masotti, A. P., Otto-Salaj, L. L., Bragg, D. A., **Treat, R.**, Simpson, D. E. (2002). A longitudinal women's health curriculum: A multi-method, multiperspective needs assessment. *American Journal of Obstetrics & Gynecology, Supplement 187* (3), S12-S14.

- Bragg, D., **Treat, R.**, Simpson, D. E. (2000). Have clinical teaching effectiveness ratings changed with the Medical College of Wisconsin's entry into the health care marketplace? *Academic Medicine, 75* (10 Suppl), S59-S61.

- Distinct heme active-site structure in lactoperoxidase revealed by resonance Raman spectroscopy. Hu, S., **Treat, R. W.** (1993). *Biochemistry, 32* (38), 10125-10130.

Peer Reviewed Workshops/Presentations

National

- **Robert Treat**, Examination of Asynchronous Communication Patterns in Online Courses and their Impact on Adult Learner Satisfaction, The American Association for Adult and Continuing Education: 55th National Adult and Continuing Conference, Milwaukee, WI, November 9, 2006.

- **Robert Treat**, Brian Mavis, Summers Kalishman, Dawn Bragg, What Should We Ask on Our Graduate Follow-up Survey? Three Medical Schools Perspectives on the Methods and Processes, Association of American Medical Colleges: Pursuing Excellence, Creating Value, Seattle, WA, October 30, 2006.

Regional

- **Robert Treat**, Rainer Gedeit, Jennifer McKanry, Karen Marcdante, Temporal Differences in OSCE Performance and Outcomes, MCW's Educational Innovations and Innovators Conference: We Practice What We Teach across the Continuum of Medical Education, Milwaukee, WI, May 30, 2006.

- Diane Brown, Tonye Teme, **Robert Treat**, Preston Roberts, Jennifer Steines, Melissa Earles, Deborah Simpson, Do Objectives = Quality Learning & Teaching, Central Group on Educational Affairs Annual Spring Meeting, Leadership & Scholarship: Across the Medical Education Continuum, Kansas City, MO, March 9-11, 2006.

- **Robert Treat**, Examination of Asynchronous Communication Patterns in Online Courses and their Impact on Adult Learner Satisfaction, Midwest Research to Practice Conference in Adult, Community and Continuing Education, Milwaukee, WI, September 28-30, 2005.

- Diane Brown, George Sanchez, Erica Samuel, Sara Mijal, Matthew Crapko, Charles DeRubeis, **Robert Treat**, Deborah Simpson, A Curriculum Audit Using Student Curriculum Auditors (SCAs): Is Injury Prevention Discussed in the Medical School Curriculum?, Central Group on Educational Affairs Annual Spring Meeting, Promoting Educational Scholarship, Collaboration, and Innovation, Madison, WI, April 7-10, 2005.

- Diane Brown, Jenny Chen, Louis Noto, Charis Thatcher, Erica Samuel, Robert Lindau, George Sanchez, Amy Hirt, **Robert Treat**, Deborah Simpson, Geriatric Training and its Impact in the Basic Science Curriculum, Central Group on Educational Affairs Annual Spring Meeting, Putting the Pieces Together: Skills for Medical Educators, Omaha, NE, March 15-17, 2004.

- Curtis Black, Kristin Black, Diane Brown, **Robert Treat**, Deb Simpson, Tobacco Smoking: Coverage in the Basic Science Courses of Medical Education, Central Group on Educational Affairs Annual Spring Meeting, Active Learning in Medical Education: Principles Into Practice, Iowa City, IA, March 20-22, 2003.

Membership in Professional Organizations

American Chemical Society (1990 - 1993)

Committee Membership at the Medical College of Wisconsin

MCW Medical Student Outcome Evaluation Committee (2006 to present)

- Redesigned graduate follow-up and resident director surveys to address changes in curriculum and link outcomes to ACGME competencies.

M3 Clerkship Directors Working Group (2006)

- Redesigned and provided evaluative support for high-stakes benchmark objective structured clinical examinations for third-year medical students.

Faculty Development in Pediatrics Committee (2004 to present)

- Provided evaluation and research support for faculty development projects in the department of pediatrics.

Genetics in Primary Care Training Program (2000 - 2002)

- Provided statistical analysis of faculty development program through which twenty faculty teams from around the country were trained.

Barbara J Daley 11/28/06

Major Professor **Date**