Impact of available interactivity options on student learning and discussions in online physics courses

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Impact of available interactivity options on student learning and discussions in online physics courses

by

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A dissertation submitted to the graduate faculty in partial fulfillment of the requirements for the degree of

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This is to certify that the doctoral dissertation of

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For the Major Program
This work is dedicated to my children


Thanks for letting me work when I needed to. I love you all very much.
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CHAPTER ONE: INTRODUCTION

Overview

The ever-increasing demand for online educational opportunities has produced a huge increase in the number of courses being offered by institutes of higher education. Community colleges are particularly affected by increased demand for online courses due to the nature of their mission to serve the entire community. Students who are not able to come to campus, either because of their work or family obligations, or because of sheer distance to the campus, are seeking ways to get their education in spite of their limitations.

The learning process, however, depends on interactions between the student and teacher and between students as they work together (Foreman, 2003). Interaction presents a difficult task in the distance classroom. How can a distance classroom provide the interaction critical for student learning to take place? Current technologies offer instructors and colleges abundant choices for designing the teaching and learning environment. This abundance itself presents challenges for instructors to design effective environments and experiences for their students. In the area of student/teacher interaction alone, an instructor can choose from a variety of media, such as email, messaging systems, blogging, listserves, threaded discussion boards, chat rooms, interactive video, ITV and teleconferencing, all of which differ from traditional face to face interaction.
Studies into the use of these technologies have catalogued the types of interactions that online students practice (Anderson, 2002; Fahy, 2001, 2003; Gunawardena, 1992; Hassenplug & Harnish, 1998). Other studies have looked at the perceived benefits of various forms of communications available to a distance student (Anderson, Banks, & Leary, 2002; Centra & Gaubatz, , Clow, 1999; Egan, Welch, Page, & Sebastian, 1992; Foreman, 2003; Frear & Hirschbuhl, 1999; Fulford & Zhang, 1993; Silvernail, 1992; Silvernail & Johnson, 1990). Little is known about the types of interaction available and their impact on student learning.

The goal of this study is to look at the extent to which the use of asynchronous and synchronous communications media is associated with student learning, student satisfaction or both as compared to similar onsite courses.

**Theoretical Framework**

Current theories about learning science focus on the processes by which students construct and change their ideas about how the world works. Many of these processes are social processes, wherein the building and refining of understanding takes place in community with others. Students come to grips with their own ideas as they work with others, whether students or teachers, to come to an agreed understanding of the concepts under consideration (Rasmussen, 2001).

The communication that takes place between students is one type of interaction that students experience in the classroom. Dewey would have talked about transactions (Dewey, 1938), rather than interactions, stressing the reciprocal
effect that one student has on another and vice versa. Others have broadened the
definition of interaction to include all of the entities of the learning environment: the
student, the other students in the class, the instructor, the content, the physical
environment, and the media of communication (Fahy, 2003; Anderson, 2002).
These entities impact each other, contributing unpredictable developments unique to
each experience. Although the specific events are unpredictable, there may be
some trends of occurrences that can be predicted or anticipated in the interaction or
transaction between two entities. In this light and for this study, an interaction will be
a communication between two entities in which the two parties are mutually
influenced (Anderson, 2002). The interactions considered will only include those
among the students, the instructor and the medium of communication.

Research Question

The goal of this study is to advance our understanding of the ways in which
online students learn and interact. The particular question under investigation is:

To what extent is student learning and development of epistemological beliefs
related to type of interaction available in the course?

Sub questions:

1. What differences in the degree of learning, if any, exist between
   students who participate in a) an online course and b) an online
course with mediated virtual class sessions and office hours in
addition to the communication tools embedded in the online courseware?

2. What differences in types of interaction used exist between students in each type of online course?

3. What differences in the degree of change in epistemological beliefs, if any, exist between students who participate in a) an online course and b) an online course with mediated virtual class sessions and office hours in addition to the communication tools embedded in the online courseware?

**Overview of Method**

Four classes of community college science students participated in the study. These consisted of two Foundations of Physical Science sections and two Introductory Physics sections. One section of each pair was presented entirely online. In these sections, students interacted with their instructor and fellow students mainly via the messaging utility of the courseware, and threaded discussion boards. Written assignments and laboratories completed at home were also completed weekly. Videos of the course lectures produced by the textbooks’ authors were available online to download and view. The other two sections were similar to the fully online sections, but in addition to the online asynchronous components listed above, the class also met virtually once a week for a 2-hour class using Centra, a video-conferencing platform that allows full 2-way audio and video
transmission among multiple sites controlled from one central location, in this case by the instructor. Both physical science classes were taught by the same instructor, and both physics classes were taught by a different instructor. Both instructors employed the same strategies in the two different sections aside from the use of the Centra component.

Each group of students was given four assessments. The VASS (Views about Sciences Survey) (Halloun & Hestenes, 2001) was given at the beginning and at the end of the course. This survey looks at the student's patterns of thought about the field of physics and about studying physics and assigns a profile to each student from “folk” to “expert”. To measure the level of learning in the content area a test over basic mechanics, the Force Concept Inventory (Hestenes, Wells, & Swackhammer, 1992) was given at the beginning of the course and at the midterm, after the units on kinematics and dynamics were completed.

Other data were collected about the participating students such as the number of credits they had earned to date, the number of online courses they had taken in the past and their current level of math, either by placement or successful course completion.

Comparisons were made between the Centra-using sections of the two courses and the non-Centra-using sections. Specifically, the achievement of the students was compared by looking at the distribution of FCI posttest scores as using the pretest scores as a correlate. The kinds of interactions in each section were determined by looking at the messages posted in the discussion boards. Each message was coded to indicate both the level of interaction (initial post, a reply or an
extension) and to the content of the message (protocol, factual or conceptual). The sections were compared based on the distributions of each type of interaction. Finally, the student epistemological* development was compared by looking at the VASS posttest profiles, using the VASS pretest as a correlate.

**Scope and Limitations of Study**

This study included students from a community college. The population may look very different from university undergraduate and graduate student populations on the basis of motivation, priorities, persistence and other potentially important characteristics. For instance, many of the community college students will be working full time, raising a family and trying to complete their education. The complexities of these and similar situations will inevitably cause some students to lessen their participation in the course or to drop out of the course altogether.

The number of participants was fairly low. Although this allowed some extra control of variables such as course design, instructional activities, etc, it does limit the application of the results to all general education without consideration of these facets. Although each section started with 28 students one section had only nine students that completed both the pretest and the posttest assessments. The others had 17 to 20 students completing both of the pretest/posttest assessments.

* Note that this paper will use the word epistemology the way the authors of the VASS use it, which may differ from the use of the word in other fields of study such as philosophy.
Both courses were physics courses, which controls some of the variability in the treatments. However it also limits the generalize ability of any conclusions to other courses, including other science classes.

**Definitions and Conventions**

In this study, the participants are grouped in several ways and are named according to the following.

**Course**—refers to either Physics 101, Introductory Physics, or Physics 104, Foundations of Physical Science.

**Section**—refers to one of the two groups of either Physics 101 or Physics 104. One section of each course used Centra; one section did not.

Although the communications under study were all mediated in some way, these will be considered as interactions. Interaction refers to one of the following:

1. Students communicating with other students such as through the messaging utility
2. Students communicating with the instructor such as via email
3. Students interacting with the content such as viewing a video lecture
CHAPTER TWO: REVIEW OF THE LITERATURE

Introduction

The purpose of this study is to determine the effects of including a 2-way audio/video conference component to an online science course on students in the course. In particular, how would the inclusion affect the degree of learning, and how would the inclusion change the type and frequency of communications employed by the students in each class. This review of the literature examines three areas of research pertinent to the study. First, an historical perspective is given on the trend toward offering online college courses, especially in community colleges. Next the recent research is presented on the importance of communication to student learning, including student to student and student to teacher. This includes an examination of theoretical frameworks used in studying student interactivity and computer mediated communication. Finally, current understanding of science learning is described.

The Proliferation of Online Courses in Community Colleges

The Mission of the Community College

In the 1960’s many regions across the United States voted to establish colleges whose primary service or mission was to provide open access to affordable education to the community surrounding the campus (Phillipe, 2000). Liberal Arts,
career training, and technical preparation programs made up common curricula for these schools across the country.

Today community colleges are charged with serving a diverse population. Diverse student demographics include age, gender, ethnic background, educational background, and reason for pursuing a college education or taking a particular course. Students as young as 15 – 16 are enrolled to get a jump on college or to enrich a home-school curriculum. Other students are recent high school graduates. Adult students include people, particularly women, reentering the academic world after an extended absence, men and women who are changing careers or advancing in their current field, and retirees who are exploring new areas of study. In spite of this diversity, several commonalities among the students can be found as well. Many of these students cannot leave their area of residence or current occupation due to family or work commitments or due to financial constraints.

These constraints also increase the demand for flexible and supportive programs of study. Many students do not have the financial resources or educational background needed to pursue degrees at 4-year institutions. Transportation issues prevent others from taking college courses offered in traditional ways (Phillippe, 2000).

**Alternative Delivery of Courses**

The demand for more adaptable programs has fueled the development not only of alternative scheduling for courses such as nights and weekends, but also
alternative delivery modes such as cable TV, online instruction and other forms of
instruction at a distance (Phillippe, 2000). These changes have made it possible for
some people to further their education who would not have been able to do so with
the traditional mode of delivery.

As more colleges include non-traditional scheduling and delivery of courses,
students’ likes and dislikes become important (Anderson et al., 2002). In a sense
the community college has become a marketplace for education, and schools
compete for student dollars. Although community colleges are public schools, partly
supported by both local and state government, they depend on student tuition. This
drives the need for developing and offering delivery options that students are more
likely to seek. According to Anderson review of research on distance education via
ITV, students return to programs they perceived as effective, but not to those they
perceived as ineffective (Anderson et al., 2002). To retain and recruit students,
community colleges must include offerings that the students will perceive as
effective. Their perception of the educational experience is important.

Educators debate the pros and cons of teaching and learning at a distance,
but regardless of the outcome of the debate, due to the mission of the community
college as well as to the opinions of their students, a population of students exist that
will or can only take courses at a distance. With this as a given, educators have the
responsibility of making these alternative courses effective learning experiences.
That is, they are charged with developing educational programs and modes of
instruction that satisfies students, while at the same time matching or surpassing the
learning that occurs in traditional classrooms.
Interaction, Distance Education and Learning

From the earliest educational studies, researchers have considered what effect instructional media have on student learning. Media go back to the slate and chalk, through paper and ink, to TV and phone, then to isolated computers and on into today's internetworked PC’s and the Internet. Rousseau one of the early educators interested in technology (mechanical arts), viewed mechanical arts as a key part of education and mental training (Pannabecker, 1995). In the process of learning mechanical skills (such as drawing) the student would gain a cognitive skill (such as hand/eye coordination) (Schmidt & Miller, 1980). By the 1970’s, Levie and Dickie were able to summarize that comparison studies of media without including the instructional strategies the media were used for were “fruitless,” and that most of education could be successful using “a variety of different media” (Levie & Dickie, 1973). As Clark suggested, researchers should not confuse instructional method with instructional delivery (Clark, 1983). Designing research around the question of which medium is best leaves out important pieces of the puzzle, such as learner characteristics, learning theory and instructional strategies, and in fact, the particular attributes of the media themselves (Lockee, Moore, & Burton, 2001).

Research in Distance Education via ITV

Early DE research looked at classes delivered by TV and then by 2-way interactive TV (ITV), where the students can talk to the instructor via telephone or microphone. Some of these courses had a host site and one or more remote sites.
Students may have been present at both the host and remote sites or only in remote sites. Researchers have conducted several studies in this type of setting. (See Anderson, Banks et al., 2002, for a review of these studies.) Russell (1999) looked at cognitive differences between the ITV students and the traditional students. He identified 355 studies measuring student achievement on various learning outcomes. His conclusion was that there was no significant difference in performance between the ITV students, both host and remote, and students in traditional classes.

Other studies have focused on the affective experiences in ITV classes. According to Anderson and Kent (2002), some researchers have concluded that the students in the remote and host classrooms were equally satisfied with their experience (Silvernail, 1992; Silvernail & Johnson, 1990). However others found that the students in the host site were generally less satisfied than their remote counterparts (Thomerson, 1995; Wheeler & Batchelder, 1996; Zarghami, 1998). Host site students cited that technological problems tended to waste their class time for the benefit only of the remote students. The host sites tended to have logistical negatives associated with the students' experiences with no perceived benefits. A third set of studies found that the host site students were more satisfied than those in the remote sites (Anderson et al., 2002; Clow, 1999; Egan et al., 1992; Gunawardena, 1992; Kochman, 1998). General lack of intimacy and face to face interaction affected the ITV remote students. They disliked the delays they had in receiving feedback, the limited amount of interaction they had with the instructor and the fact that the instructors were unable to monitor the verbal and non-verbal cues of the students and that the instructors seemed less enthusiastic.
In a majority of these studies, communication issues were cited as a key issue in the student experience. In fact one interesting finding in the Anderson and Kent study was that students seemed unable to separate the teacher's effectiveness from the effectiveness of the technology or method of delivery (Anderson et al., 2002; Anderson & Kent, 2002). More study was needed in the area of interaction and learning in this environment.

The Need for Interaction in Learning

Interaction and communication play a key role in several current learning theories. Several flavors of constructivist thought focus on interactions variously among the student, the instructor, the environment and technology. The following outlines the development of theories that are relevant to this study.

John Dewey

Early in the 20th century, John Dewey's work marked a beginning of a way of schooling wherein students were given the environment and tasks that would allow them to learn about ideas in various areas of their life, including the sciences, social constructions, art and literature, and commerce, to name a few. Key in Dewey's ideas were that learning and knowing was characterized by the students' active engagement and excitement about how an idea would play out, what would happen "if", or how a specific task could be done. Although certainly action or activity was the medium of this learning, communication among the group brought about the development and implementation of the process (Dewey, 1916).
In the next 100 years, Dewey’s school was studied, talked about, referred to and claimed by different educator groups. His ideas seem to include several theoretical components central to many learning theories: student-centered learning, learning communities, situated learning, construction of knowledge, and learning by doing (Fox, 2001). Dewey’s pragmatism directed the selection of items that could or should be included. For instance, some of the more extreme constructivist theories suggest that the only valid concepts are those that originated in the students themselves (Wong & Pugh, 2001), whereas for Dewey, the origin of the ideas (rather than concepts) did not matter—it was what those ideas brought to the process of learning that were important and how they engaged the students’ thought and emotion “Ideas are worthless except as they pass into actions which rearrange and reconstruct...the world in which we live.”(Dewey, 1929).

Mental processes occurred in the medium of the environment in which the person abides. For social creatures, that environment is social. Communication had to occur between and among students, between the students and the instructors, and between the students and the materials or environment with which they were working (Dewey, 1916). To Dewey knowledge was not a package simply transmitted from instructor to student. As he states in Democracy and Education,

*The development within the young of the attitudes and dispositions necessary to the continuous and progressive life of a society cannot take place by direct conveyance of beliefs, emotions, and knowledge. It takes place through the intermediary of the environment... The social environment consists of all the activities of fellow beings that are bound up in the carrying on of the activities of any one of its members. It is truly educative in its effect in the degree in which an individual shares or participates in some conjoint activity.*(Dewey, 1916)
The process of learning was a social activity built by the communication and cooperation among its participants.

**Constructivism**

The term constructivism refers to a learning theory that reflects a broad spectrum of learning variations. They all share the idea that knowledge is built by the learners, either individually or cooperatively, and that learning depends on the experiences of the learners (Windschitl, 2001). Cognitive constructivism is based on the idea that learning is the building of knowledge and understanding within the individual learner.

When learners encounter experiences that do not fit their prior understanding, they either reject the experience as an anomaly, alter the new idea so that it is congruent with prior ideas, or change prior ideas to fit the new experience. Teaching in a manner that helps students alter prior naïve so that they can develop accurate scientific understanding is called teaching for conceptual change (Posner, Strike, Hewson, & Gertzog, 1982). Such teaching requires that students be dissatisfied with prior ideas and have a new idea available that is intelligible, plausible an fruitful (Posner et al., 1982). Cognitive constructivism helps explain why students often struggle to understand fundamental science ideas, particularly in physics. Many science ideas are counterintuitive (McDermott, 1984), and do not fit with students everyday experience. Therefore, science learning requires students to do far more than take information and assimilate it with their prior knowledge; it requires a reorganization of that which they already know (Driver, 1994; Driver & Easley, 1978).
Social Theory

Social Learning theory considers learning to occur in the social group itself, not in individuals. As students talk and interact, they form and develop a group understanding of the concepts at hand. As with Dewey, knowledge was not a discrete package to be transmitted from one entity to another, but was a dynamic understanding built within the interactions of the group members. In this theory, knowledge resides in the group setting and the group interaction.

Social Constructivists integrate the ideas of constructivism and social learning. In this framework, learning is built by individuals, triangulating with a social group to verify and expand the individual's understanding. Vygotsky is a leading theorist who belongs in this area (Vygostky, 1978). One of his key themes is that higher order thinking processes of individuals originate in social activity (Moll, 1990). Learning is not a single isolated event, but a series of events from hearing and talking about an idea or watching someone else's skills, through the internalization of an idea or skill. As the learner interacts with adults or experts, the learner can play with concepts. As interaction continues, concepts will be integrated into the psychology of the learner. These processes take place in a social space that Vygotsky terms a "zone of proximal development". It is in this space that the interactions can take place among the learners and the experts to allow the ideas to develop and become part of the learners' understanding of the concept.
Interaction Theory

Interaction and interactivity have layers of meaning, even when limited to the field of education. Fundamentally, they are talking about an exchange between two entities. However, they can refer to a large set of entities, including humans, computer software interfaces such as buttons and links, menu options or virtual classrooms, or the physical environment of the student. When studying the effects of interactions and interactivity on learning, the first step is to define (or limit) the types of interaction being considered.

There are four entities that have been considered as participants in interaction. These are Students, Instructors, Materials or Content, and Technology or Interface. Interactions can be between any two of these or be reflexive. This gives ten categories of interactions that can occur. Muirhead and Judah’s review of the literature in this area concluded that there are six primary categories that are used in instruction (Muirhead & Juwah, 2004). These are student-student, student-teacher, student-content, student-interface, teacher-teacher, and content-content. To provide an effective learning experience for a variety of learning styles and backgrounds, the design should be “predicated on a blend of interactions.”

Sims uses three levels of interactivity to categorize interactions in computer mediated instruction. The lowest level is reactive. At this level the system makes all of the navigational and instructional decisions. In terms of courseware, a purely drill-and-practice program would be at this level since the program selects what the student needs to work on and where the student should go next. Above this is the proactive level, in which the student makes all of the instructional and navigational
decisions. Many children's educational computer games are at this level where the child can explore at will and play whatever games they choose. The highest level is the mutual level. In this level both the student and the system make both navigational and instructional decisions. Courseware is becoming more mutual as the technology allows more complex programming to play out in real time. Sims (1995) quotes Schwier and Misanchuk (1993) that “the levels of interaction are based on the instructional quality of the interaction,” adding that, as Spector says, “the critical factor of learning effectiveness is more likely the learner’s mental engagement or involvement with the subject matter.” (Sims, 1995) So, higher levels of interaction can enhance learning if or because it increases the students’ engagement with the content. Thurmond (Thurmond, 2002) echoes this, stating that interaction is “the learner’s engagement with the course content, other learners, the instructor, and the technological medium used in the course... (resulting) in a reciprocal exchange of information.”

Yacci (Yacci, 2000) identifies some major characteristics of interactivity, among these that the message loop originates in the student and isn’t complete until it returns to the student, and if instructional, interactivity will yield content learning and affective benefits. This highlights the centrality of the student’s participation in the conversation, but also stresses the importance of mutuality.

Ultimately these considerations are meant to inform instructional design, especially in online courses. The interactivity of the course and courseware should bring about meaningful interactions for the student. A variety of modes of interaction should be available to address student preferences and learning styles. That being
said, how does an instructor decide on what to include? Terry Anderson offers the "Equivalence Theorem" as a framework for such decisions (2002). His theorem asserts that:

Sufficient levels of deep and meaningful learning can be developed as long as one of the three forms of interaction...is at very high levels. The other two may be offered at minimal levels or even eliminated without degrading the educational experience. High levels of more than one of these three modes will likely deliver a more satisfying educational experience, though these experiences may not be as cost or time effective as less interactive learning experiences.

Anderson includes student interactions with students, the instructor and the content as the "three" modes. Other interactions are not included in this equivalency theorem.

Based on these ideas it is reasonable to design courses by choosing the most effective communications and interactive tools in a variety of modes to offer students rich learning experiences, even in a virtual environment.

**Research on Internet Courses**

The first internet or web-based courses were offered in the early 90’s, before the existence of web browsers. This type of distance instruction quickly became a focus of research. Recent studies have been conducted comparing classes using asynchronous communication tools, including threaded discussion boards and email. Fjermestad, Hiltz and Zhang (Fjermestad, Hiltz, & Zhang, 2005) analyzed 47 empirical studies of “asynchronous learning networks”. The researchers selected the studies to analyze that met certain criteria for rigor. The classes involved had to
be largely asynchronous learning networks, requiring interaction among the students and instructor online asynchronously. They were all empirical, meaning that one or more hypotheses were stated, data was collected and the results of the hypothesis testing were given. All of the studies looked at the effectiveness, either for student or instructor learning or satisfaction, of the asynchronous learning network class compared with a face to face class. The results of the meta-analysis were that 16 indicated asynchronous learning network produced significantly better results on objective measures, 29 showed no significant differences between the asynchronous learning network and face to face classes. Of the 47 studies, two indicated that the face to face students performed better than the asynchronous learning network. To summarize these, asynchronous learning network courses were found to be at least as good if not better than face to face in 95% of the studies selected.

As part of their meta-study, Fjermestad, Hiltz and Zhang also considered 12 studies of student satisfaction relative to class format. Of these, five found asynchronous learning network students more satisfied than face to face students, four showed no significant difference, and three indicated that the face to face students were more satisfied. Thus a clear picture of “what students want” has not been determined. Taking either type of college course is a complex activity, and it is probable that breaking the areas of satisfaction studied into specific aspects would yield more helpful results. For instance, asynchronous learning network students might be more satisfied than face to face with the access they have to course
materials, while face to face students might be more satisfied that they had timely feedback from the instructor.

Critics of the above studies have cited a flaw in design that often is present in purely "media" studies. These critics argue that it is not the medium itself that might affect the outcome, but rather how the medium is used, or how the medium changed the instruction. The majority of the studies were seen to yield "no significant difference." This does not indicate that the treatments or paths were equivalent, however. These results merely indicate that based on that data, no difference could be found, even though some difference may indeed be present that the data did not indicate (Lockee et al., 2001).

This opens up the field for research into the different ways of using a given medium and how those instructional practices have impacted the student’s experience and learning. For online education, there have been many studies on asynchronous learning networks that did not compare media, but analyzed how the media were used. Each type of communication medium has its own characteristics, and when added to the variety of instructor behaviors, strategies, skills, and preferences and to the particular subject matter of the course, making broad statements about the effectiveness of one type over another becomes very difficult. Recently, researchers have studied individual applications of media, specific to a course, instructor and environment to look for trends that could help educators make choices for their own courses. Four are particularly relevant to the present study.

A study from 1998 looked at the nature and importance of interactivity in a two-way audio and video course taught from one site to several other sites in a
state-wide communications network (Hassenplug & Hamish, 1998). This type of course is synchronous, not mediated by a course site. This study looked for the impact of student/instructor and student/student interactions on student satisfaction and perception of course quality. Comparisons were made based on student and faculty satisfaction and attitude survey results. A key finding (relative to the present study) in this was that remote students reported more negative experiences with the various types of interactions, but were satisfied with the overall experience. This could support the idea posited by Fulford and Zhang (1993) that it is the perception of interaction, whether vicarious or overt, that impacts student satisfaction with the course. Hassenplug and Hamish also offer the suggestion that interactivity was not a critical factor compared to others in the distance student's overall satisfaction.

Another study looked at two courses taught via the Iowa Communications Network (Collins & Pascarella, 2003). In this case, students were randomly assigned to either on-campus or distance instruction in a Fire Science course. In addition, some students signed up for the same course from areas around the state. This gave a way to compare the students who chose to take a distance course with those who did not knowingly choose this. Based on a 61-item objective exam given as a pretest and a posttest at the end of the course, the randomly assigned groups showed no significant difference. The distance students had less than a one-question advantage over the on-campus students. However, the students who chose the distance course averaged about five to six questions ahead of the randomly-assigned students. Collins and Pascarella assert that self-selection is a factor that confounds many research studies in education.
The Constructivist on-line Learning Environment Survey was developed by Peter Taylor and Dorit Maor at Curtin University of Technology in Australia (Taylor & Maor, 2000). This questionnaire was designed to find each student's preferred online learning environment and compare this with the student's actual environment. The dimensions measured were the students' perception of professional relevance, reflective thinking, interactivity, cognitive demand, affective support and interpretation of meaning. The survey was given at the end of a 15-week semester to graduate students in an online education course. One result from this preliminary study was termed the "anomaly of interactivity." What the researchers saw was that students prefer to interact "less than often," but that the requirement of participating in discussions that rotated bi-weekly was perceived as "only sometimes" having the opportunity to engage in discussion with other students. The researchers suggest that perhaps students viewed the required discussion as monologue rather than dialogue, and that perhaps students needed more direction to overcome this.

Rovai studied 326 adult learners in graduate and undergraduate programs in urban universities (Rovai, 2002). Using the Sense of Classroom Community Index (SCCI) he looked for differences in the sense of community between two groups, one group of students in traditional face to face classrooms, and one group of students in asynchronous learning classrooms. The students were given the SCCI at the end of a 16-week semester. The total scores were not significantly different comparing the online and oncampus courses, suggesting that the overall feeling of community was not significantly different. The scores differed in variability, however. Rovai suggests this shows that the sense of community is more sensitive to design
and pedagogy differences between online courses than between on-campus
courses. Looking more closely at the factors of that the SCCI selected, differences
were seen. Traditional courses had higher averages in similarity of learner needs,
connectedness, friendship and group identity, and lower average in need to reduce
confusion. Online courses were higher in student sense of recognition, the
importance of learning in the course, thinking critically in the course, safety and
acceptance. Rovai suggests these are directly related to the reflective nature of
communication often seen in computer mediated discourse. The study did not
control for instructor practices or student self-selection, but the courses themselves
were randomly selected from the online and on-campus courses offered at these
universities.

Booth and Hulten analyzed group discussions in a web-based engineering
course where groups of students designed a self-guided vehicle.(Booth & Hulten,
2003) The analysis looked in detail at what types of messages could be seen to
bring about “learning” in the group. They found that four types of contributions led to
learning: Participatory, factual, reflective and learning. By identifying the learning
message or pivotal point in the discussion they were able to consider what types of
contributions led up to them. This analysis gives educators a tool for reflecting on
the interactivity in their own course discussions.

Fahy has conducted analyses of online discussion with the aim of developing
a standard coding system that would facilitate comparisons of results from different
researchers (Fahy, 2001, 2002, 2003). The TAT (Transcript Analysis Tool) gives
each sentence in a message a functional label. These are: vertical questions,
horizontal questions, non-referential statements, referential statements, reflections, scaffolding and engaging, quotations and paraphrases and citations. In the 2003 study, he used this tool to look for supportive messages in a number of discussion board transcripts. Within these messages, specific behaviors were identified and analyze. The results of this study were that the most frequent indicators of support were referential statements, signatures, greetings and horizontal questions.

The research on computer mediated instruction, interaction in distance courses and asynchronous learning networks is rich. Even so, research into how the interactions occur and how they impact learning, into what instructors can do to have more effective online communications, and into how to use technology in ways that bring about satisfying and enriching educational experiences for students.

**Goals of Science Education**

The objective in designing instructional interaction is to enhance learning. The effectiveness of instruction interaction is tightly bound with the content of instruction. Different fields of study have different “best practices” concerning what is effective for students in that particular area. The present study concerns two college physics courses. This brings about the need for discussion on science and physics instruction.

Science instruction is focused on the major goal of science literacy—the development of a broad understanding of scientific knowledge, an understanding of how science works, an the enhancement of students' ability to view the world
scientifically. The first of these goals involves the fundamental content of the scientific discipline under study, while the second involves an understanding of the nature of science, and the third involves thinking critically in a way similar to scientists in the field.

In the past two decades several organizations have generated sets of standards for teaching science at various educational levels. The National Academy of Sciences (AAAS) produced the *National Science Education Standards*, which present its recommendations for learning outcomes, teaching methods and assessment of science (NRC, 1996). The American Association for the Advancement of Sciences published its *Benchmarks for Science Literacy* and *Project 2061.* (AAAS, 1989, 1993) The National Science Teachers Association’s contribution was the *Science Scope and Sequence* publication (NSTA, 1992). These various documents present a consensus of sorts about what “ought” to be taught in science, and in particular what ideas about science should be understood by our students. At the undergraduate level, AAAS also develop a document called the Liberal Art of Science, outlining organizing themes and pedagogy appropriate for a liberal education in the sciences (1990). Each of these documents calls for teaching to focus on depth rather than breadth, with a concentration on student understanding of fundamental science ideas rather than a memorization of facts.

Studies of physics instruction and learning in the past 20 years have shown that not only do students come into the science classroom with alternative ideas about physical phenomena, but that these interact significantly with the scientific ideas that are being studied and that some of these preconceptions are very
resistant to change. Cognitive research, based on conceptual change teaching approaches to physics education (Clement, 1982; Halloun & Hestenes, 1985; Hestenes et al., 1992; Larkin, 1980; McDermott, 1984; Mestre, 1991) has generated a taxonomy of the misconceptions or alternative ideas about the physical world, how these misconceptions interfere with student learning and strategies for overcoming these alternative ideas within the topic of mechanics, especially kinematics.

Physical models and definitions of motion in the scientific arena are clearly not congruent with the alternative ideas of motion that students generally have when entering a physics course. Preconceptions that interfere with student learning include explicit definitions of velocity (such as distance divided by time), the idea that when an object reaches the top of its trajectory (momentarily coming to rest in the vertical direction) that no acceleration exists, no recognition of the difference between velocity and acceleration, and no recognition that changes in direction imply acceleration.

Students' understanding of the nature of science an how knowledge develops is also fraught with problems (McComas, Almazroa, & Clough, 1998). Students often believe that scientific knowledge is decided democratically, that science ideas can rest on the assumption of an interfering deity, and that ideas in science are "out there," waiting to be discovered through the perfect experiment (Matthews, 1993). Halloun assessed students' understanding of physics knowledge and how it develops, comparing students' to scientists' and science teachers' views (Halloun, 1996). They found that a majority of students had ideas they categorized as "folk" or "low-transitional" on a scale that rated ideas from "folk" to "expert."
Conclusion

Looking at today's community college mission and scope, it is clear that Distance Education will continue to develop and become more common not just for adult students or geographically distant students, but also the traditional student. Current trends show that the age group of 18 – 24 make up the largest growth area for taking distance education courses (Phillippe, 2000). Many cite the flexibility of the scheduling that allows them to get a course into their schedule where a traditional class would not fit. Others are working while going to school, and can accommodate both with an online class.

This trend increases the need for well-grounded course design based on sound research in how instructor choices will impact the student's experience. In particular there is a need to study how instructors and schools can use technology to give the students the best possible learning experience.
CHAPTER THREE: METHOD OF STUDY

Overview

Since the first studies of distance courses were done in the 1970's, instructors have been encouraged to integrate communication and interaction into their course. Professional development materials have been designed with a variety of activities and strategies for instructors based on the importance of this type of interaction. So far, however, research into the specific details of the types and the frequency of interactions that are most effective are scarce. One type of communications application attempts to replicate an oncampus or face to face classroom experience by making use of current technologies that allow multi-site audio and video combined with interactive web-based software tools such as whiteboards and application sharing. The present study investigates the effectiveness of the use of such a virtual classroom system for virtual instructor office hours and for group instruction in online science courses.

This study examined two science courses, each with two different sections, one of which made use of a video conferencing system, Centra Symposium, for up to four hours each week. The other section of each course was an online course conducted without using any synchronous group instruction or communication.

Students of all sections were given two surveys and two tests at various points in the course to give feedback into the epistemological and cognitive aspects of their learning. In addition, the course discussion board records were analyzed to
determine the type of the students' interactions. The results will help inform instructors as they design their own courses for use in various venues.

**The Research Question**

To what extent is student learning and development of epistemological beliefs related to type of interaction available in the course?

Sub questions:

1. What differences in the degree of learning, if any, exist between students who participate in a) an online course and b) an online course with mediated virtual class sessions and office hours in addition to the communication tools embedded in the online courseware?

2. What differences, if any, exist in the types of interaction used between students in each type of online course?

3. What differences in the degree of change in epistemological beliefs, if any, exist between students who participate in a) an online course and b) an online course with mediated virtual class sessions and office hours in addition to the communication tools embedded in the online courseware?

**Participants**

The study was conducted in a Midwestern community college that serves a suburban and urban population. The students come from a variety of backgrounds
and take courses for a variety of reasons, from satisfying a personal interest to working towards a certificate or two-year degree to completing a transfer program to a four-year institution. All of the students were enrolled in a general science course that satisfies the General Education requirement (required in most two-year programs) of a laboratory physical science. There are no prerequisites for the courses, although students are encouraged to be ready for or placed beyond the college algebra level in math.

The first group of students was enrolled in Physics 101, Introductory Physics, which is offered online via Blackboard. The course is a largely non-mathematical survey of the topics of classical mechanics, electricity and magnetism, and light. The course is designated as a five-credit course, with four hours of lecture and two hours of laboratory per week of a sixteen-week course. The laboratory component of the course is completed at home using a laboratory manual that is a companion to the textbook, materials from around the house and a packet of more specialized items that is sent to each student at the beginning of the semester.

The second group of students was enrolled in Physics 104, Foundations of Physical Science which was also offered online via Blackboard. This is also a largely non-mathematical or conceptual science course. About 60% of this course covers the same content as introductory physics. It also includes a survey of topics in chemistry, and earth and space science. Foundations of Physical Science, like Introductory Physics, is designated as a four-hour lecture and two-hour laboratory class. Students complete laboratory assignments at home with household materials
and special laboratory packets again being mailed or handed out at the beginning of
the semester.

Each of these courses had two sections, one with Centra available and the
other without. For both sections, students were required to attend a one-time
orientation at the beginning of the semester, but otherwise participated at a distance
throughout the semester, that is, via Blackboard, phone calls or e-mail. Both of the
Introductory Physics sections were taught by the same instructor, using the same
techniques, assignments, time line and website for both sections, with the exception
of Centra. A second instructor taught the two sections of Foundations of Physical
Science also using the same techniques, assignments, time line and website for
both sections, with the exception of Centra.

In one section of each course, students could participate in a full class video
conference each week for two hours, as well as virtual office hours with the
instructor using the same video conference system for up to two hours each week.
The video conference class and office hours were regularly scheduled but not
required. They were conducted using the Centra Symposium system, which allows
complex communication to occur among multiple sites. The minimum requirements
of the computer system were posted on the college distance education home page,
and were the same for both the Centra and non-Centra sections. In addition,
students in the Centra section were given the opportunity to check out a headset
and a video camera through the media center on campus. Students in the physical
science classes were not aware of the possible use of Centra prior to signing up for
the course. Both sections of the physics course were aware that Centra might be
used. No specific meeting times or required online times were set for any of the sections, other than the one orientation meeting at the beginning of the semester. Both sections of both classes were filled within the first week of registration, and several students in each section were changed through add/drop processes before the beginning of class.

Both of the courses historically have the same makeup of students in general, although this aspect was investigated. Across both courses, 68% were female. Physics (Physics 101) had 65% female and physical science (Physics 104) had 70%. The students in physics ranged in age from 18 – 52, with an average of 27 years. Those in physical science ranged from 19 – 50, with an average of 29 years. Each course enrolled 28 students, and historically has a 70% completion rate, slightly less than the district average online completion rate of 76%. District completion rate overall is about 80%.

Each student’s demographics were obtained from the Office of Research and Development at the college. These were used to assign other categories to each student based on:

1. The number of credits earned to date
2. Math level at the beginning of the course, either by placement or by last class passed
3. Number of online courses taken to date

Summary demographics for these courses are given in Tables 3.1 – 3.3. A total of 65 students participated in and completed the study
<table>
<thead>
<tr>
<th>Factor</th>
<th>Category</th>
<th>% in Each Category</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td></td>
<td>Male</td>
<td>29.2</td>
</tr>
<tr>
<td>Number of online classes</td>
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<td>53.8</td>
</tr>
<tr>
<td></td>
<td>1 – 2</td>
<td>21.5</td>
</tr>
<tr>
<td></td>
<td>3 or more</td>
<td>24.6</td>
</tr>
<tr>
<td>Number of credits</td>
<td>0 – 15</td>
<td>27.7</td>
</tr>
<tr>
<td></td>
<td>16 – 30</td>
<td>23.1</td>
</tr>
<tr>
<td></td>
<td>31 – 45</td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td>46 and up</td>
<td>24.6</td>
</tr>
<tr>
<td></td>
<td>Missing Data</td>
<td>10.8</td>
</tr>
<tr>
<td>Math level completed or by placement</td>
<td>Below college Algebra</td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td>College Algebra</td>
<td>18.5</td>
</tr>
<tr>
<td></td>
<td>Completed College Algebra</td>
<td>26.2</td>
</tr>
<tr>
<td></td>
<td>Missing Data</td>
<td>41.5</td>
</tr>
</tbody>
</table>

Table 3.1. Participant distribution
<table>
<thead>
<tr>
<th>Table 3.2. Participants in each section of the study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Participants</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Females</td>
</tr>
<tr>
<td>Males</td>
</tr>
<tr>
<td>Mean Age</td>
</tr>
<tr>
<td>Median Age</td>
</tr>
<tr>
<td>Mean Number of Credits</td>
</tr>
<tr>
<td>Median Number of Credits</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3.3. Participants in each group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Participants</td>
</tr>
<tr>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Females</td>
</tr>
<tr>
<td>Males</td>
</tr>
<tr>
<td>Mean Age</td>
</tr>
<tr>
<td>Median Age</td>
</tr>
<tr>
<td>Mean Number of Credits</td>
</tr>
<tr>
<td>Median Number of Credits</td>
</tr>
</tbody>
</table>
Distributions of these factors for each section were plotted. Figures 3.1 to 3.3 present the box plots for each of the factors. Analyses were done looking for differences in the distributions for each of these factors. No significant differences were found.

Figure 3.1. Distributions of cumulative hours by section
Figure 3.2. Distributions of previous online courses by section

Figure 3.3. Distribution of age by section
Instructional Components

Instructors used the interactive system in the Centra sections to conduct a virtual class for two hours each week and to hold virtual office hours for two hours each week. The students needed to log in early for the first session to allow time for the automatic software installation. The link was available through the course website to give as seamless an experience as possible. The Centra software itself did not require webcams or microphones. Students could use the text chat feature to communicate instead. For those who wanted them microphones and/or webcams could be checked out from the library (also available via mail) for the semester. Many students already owned this type of equipment. The two-hour class was used for discussion of specific concepts with which the students were having trouble, for problem solving, for discussion extending the concepts of the class, for didactic instruction, and for general communications about logistics in the course. Each session was recorded and the recordings were posted and made available to the students in that section of each course. The recordings did not require any special software to play and the autoplay feature allowed fast-forward and rewind to replay specific sections of the class. The sections that did not use Centra were otherwise given the same opportunities and requirements that the Centra sections were given. These are described below.

Both the Introductory Physics course and the Foundations of Physical Science course were organized in modules. The Introductory Physics course is designed with six modules, while the Foundations of Physical Science had seven.
Each module included study activities as well as required graded activities. Non-graded activities included a reading assignment covering about four chapters in the ninth edition of Paul Hewitt’s Conceptual Physics textbook (Hewitt, 2002) or from the third edition of Hewitt, Suchocki and Hewitt’s Conceptual Physical Science text (Hewitt, Suchocki, & Hewitt, 2004). Suggested workbook pages were given as well as a list of exercises, problems and short activities to complete. Students were given access to the solutions to these and were encouraged to ask and answer questions on the general discussion board for each module. Paul Hewitt’s lectures were available for each chapter included in the study for the students to watch online or for checkout from the physics department. Each of these videos showed short demonstrations conducted by Paul Hewitt, along with his very accessible discussions or lectures on each topic.

Whereas the activities just described were not graded directly, the assigned laboratory activities were submitted for a grade. These were assigned from the Physics Laboratory Manual or the Physical Science Laboratory Manual that accompanies the textbooks. Most of the laboratories assigned used household materials or those that could be purchased inexpensively at the grocery store. More specialized laboratory equipment was given or mailed to each student for those laboratories requiring it. Students also had the option of checking out laboratory materials from the physics department.

For each module, a set of group discussion questions were given to foster discussion about the concepts under consideration. Topics included “what-if” questions or application questions that pertained to the material of the module,
global cultural application questions, and short laboratory activities that the students could complete at home. Students were required to post at least three substantive comments per module, at least one of which responded to another student's message.

Students could also communicate with each other and with the instructor through the messaging utility embedded in the courseware. Of course students could use direct contact methods such as personal visits, telephone calls and email external to the courseware.

At the end of each module, students completed an online quiz. These were taken individually with a 90 minute time limit. The quizzes varied from student to student by randomly assigning each question of quiz from a large pool of questions.

The courses involved in this study followed the course requirements and opportunities given in the courses during previous semesters. Additional credit was given to each student in the study who took the surveys and tests associated with this study, regardless of the earned score. Students could take these surveys and tests whether they agreed to participate in the study or not.

**Instrumentation**

Two instruments were used for this study. The first is the Views about Sciences Survey (VASS) developed by Ibrahim Halloun at the University of Arizona (1996). The instrument includes 33 items that are used to assign a profile to the test-taker. The profiles are "folk", "low-transitional", "high-transitional", and "expert",
indicating the degree to which the person’s views about science are aligned with the views held by experts in the field. Different versions of this instrument are available for use in different courses by discipline. The version used in this study was P20, for physics. This instrument was used to determine each student’s epistemological perspective, and the student’s profile was used as a categorical variable in the analysis of the other test results.

The VASS was administered both as a pretest at the beginning of the semester and a posttest given at the end of the semester. The test was set up as an online quiz. The students were not given access to the survey or their score after completion, but a “complete” indicator was recorded, which was interpreted as full credit.

The second instrument was the Force Concept Inventory (FCI), developed by Hestenes and Halloun (1985), given as a pretest and as a posttest. The items of the test represent topics covered in both classes, although the physics class spent more time on these topics. The pretest was administered in the first week of class, and the posttest administered upon completion of the unit on Classical Mechanic about six weeks into the course. Both tests were set up as online quizzes. The students did not have access to the test or their scores after completing them, but completion indicators were recorded. The FCI posttest score was used, correlated with the pretest scores, as an indicator of the degree of learning that occurred during the unit on mechanics.
**Discussion Board Data**

The second set of interactivity data included the messages which were posted on the General Discussion Boards and the Group Discussion Boards. Email and messaging also occurred, but were not analyzed.

The General Discussion Boards were set up similarly for all sections. Each class site had a forum set up for each module. In addition there was a forum set up as a virtual student lounge that was for extra-curricular discussions. These forums were not used by more than one or two of the students in any of the sections. Due to these small numbers, these forum postings were not included in the data set.

Physics 101 (physics) students were assigned to groups of from six to ten students for discussion of the content among themselves. In these Group Discussion Boards, the students were given several questions from the instructor to discuss. In addition, there were several short activities that could be used as topics of discussion, or students could begin their own topics. The groups were grouped to maintain at least six actively enrolled students in each group.

Physical science students were not divided into groups per se. Each module had several laboratories that the students were to choose from. Each laboratory was worth a certain number of points and students were to select activities that would add up to a total of 20 points. Then each student was to post a message regarding the laboratory on the Group Discussion Boards. A group was set up for each separate laboratory activity. Thus students self-selected the group(s) they were in.
Both physical science and physics had the same requirement of posting at least three substantive messages on the Group Discussion Board to receive full credit. At least one of these was supposed to begin a new thread and at least one was to be in response to someone else's discussion.

**Process of Data Collection:**

At the beginning of the course, the students were introduced to the project and given the opportunity to participate by signing an informed consent form. Within the first week of class, the participants were given two tests: VASS and the FCI pretest. The following six weeks were spent studying classical physics from a conceptual perspective. When this topic had been completed, in the seventh week of class, the participants were given the FCI posttest. This was integrated within their regular testing process to provide as authentic a test score as possible, although the FCI test scores were not used in the calculation of their course grades. Four to five weeks later, the students again took the VASS posttest.

Two sets of discussion board postings were studied. The first were the general class discussion board, where students were encouraged to post questions and answers about the content or course and to interact with each other. A second set of discussion boards were set up for small groups, where specific application or laboratory activity questions were given as discussion topics. In these Group Discussion Boards, each student was required to post at least three "substantive" postings per unit, both beginning a thread and responding to other student's
postings. The number of postings was recorded for each student. Following the collection of the postings, they were analyzed for content as described below. These were then totaled for each student and for each section.

**Quantitative Analysis**

The numerical data consist of student scores in four groups based on treatment and course: Centra and non-Centra in physics and physical science. For each student the scores included: 1) FCI scores for the pretest and posttest and 2) VASS scores for the pretest and posttest. The null hypotheses were that there would be no significant differences between treatment group means in either course on the two posttest scores defined above, using the pretest scores as their respective covariates.

The first set of statistical tests was conducted using data from all the subjects who participated in the study. Populations were tested for homogeneity. A second set of tests was conducted using only the student who completed the courses. These populations were also tested for homogeneity.

ANOVA s were conducted to compare the means of the FCI posttest scores between the Centra and Non-Centra sections. These were conducted for each course individually (physics separately from physical Science) and then with the data pooled for both courses. A similar analysis was conducted for the VASS posttest scores.
**Qualitative Analysis**

Each section of students participated in general Discussion Boards as well as Group Discussion Boards. The study considered messages posted during the first three modules of the course, corresponding to the same time interval of the FCI pretest/posttest assessments. This part of the course consists of about ten forums for each section over the course of five to six weeks.

The messages were considered for their level of content as well as their level of interaction. The content levels were given the labels of

a. Protocol and logistics

b. Factual information

c. Conceptual information

The interaction levels were given the labels of

1. Initiating statements or questions

2. Responses

3. Extensions from students' messages

4. Extensions from instructor's messages

This coding system yielded twelve separate categories one of which could be assigned to each message. A specific description of each of these twelve categories is given in Table 3.4. The content levels were defined to try to identify the goal of posting the message. Some messages were simply asking for help finding a tool or link. Others were looking for answers to homework or quizzes. Of these,
many were posted so that the student could complete an assignment or quiz. The rest were looking for explanations of why the answers were the way they were. These levels indicate the depth of learning the student was engaged in at the point of communication.

The interaction levels were used to identify points where the discussion was ongoing, beyond simply a question and then an answer. Threads that reached level three or four indicated the participating students were engaged in these discussion ideas.

Each message was coded at the message level and recorded according to the student who posted it and in which section of the study it was posted. Each message was thus labeled with an indicator of the level of engagement of the student in learning. The highest level of engagement in learning was indicated by a level 3c or 4c. The lowest level would be level 1a. The data were then totaled for each student and each section. Various comparisons were conducted, looking for trends in the number of and level of messages posted by student and by treatment.
<table>
<thead>
<tr>
<th>Content level</th>
<th>Interaction level 1</th>
<th>Interaction level 2</th>
<th>Interaction level 3</th>
<th>Interaction level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content level a</td>
<td>Student or instructor initiates a thread about protocol or logistics</td>
<td>Student or instructor responds to a message about protocol or logistics</td>
<td>Student or instructor makes an extension to a student's message about protocol or logistics</td>
<td>Student or instructor makes an extension to an instructor's message about protocol or logistics</td>
</tr>
<tr>
<td>Content level b</td>
<td>Student or instructor initiates a thread focusing on factual information</td>
<td>Student or instructor responds to a message focusing on factual information</td>
<td>Student or instructor makes an extension to a student's message focusing on factual information</td>
<td>Student or instructor makes an extension to an instructor's focus on factual information</td>
</tr>
<tr>
<td>Content level c</td>
<td>Student or instructor initiates a thread getting at conceptual information</td>
<td>Student or instructor responds to a message getting at conceptual information</td>
<td>Student or instructor makes an extension to a student's message getting at conceptual information</td>
<td>Student or instructor makes an extension to an instructor's message getting at conceptual information</td>
</tr>
</tbody>
</table>

Table 3.4. Definitions of codes used for discussion messages
CHAPTER FOUR: RESULTS

The goal of this study is to investigate the impact of the use of the Centra Symposium system in four online college science courses. This chapter outlines the process of analyzing the data. The analysis can be broken into two parts: Effect on content and epistemological measures, and impact on type and frequency of discussion board postings.

The first section of this chapter will discuss the data and analysis for two measures. The Force Concept Inventory is an instrument developed by Hestenes, et al, (1994) to measure the conceptual learning of physics students in the area of classical kinematics and dynamics. This was given to the students as a pretest prior to and a posttest following instruction and study of classical mechanics. The Views about Science Survey was developed by Halloun (2001) to measure several dimensions of students’ epistemological beliefs. This was also given in a pretest-posttest sequence. The data analyzed consisted of these data, along with demographic information about the students.

The second section of the chapter considers the communications postings from the students during the course. The student postings in each class are analyzed for trends in frequency and content in each class. The postings are coded according to the type of communication presented in each. The two sections using the Centra system are compared with the two sections not using the system.
*FCI and VASS*

The four sections were from the same Midwestern suburban community college and each course had 28 students initially enrolled. Some of the students in these classes did not complete all four tests, did not complete the course up to the sixth week, or chose not to participate in the study. Total number of participants in each course is shown in Table 3.2 with a total of 65 participants in all.

In this data, the number given is the number of students who completed at least one pretest/posttest pair. The profiles look very similar for the first three classes, but the fourth class has fewer participants than the others. This difference was considered in the analysis by comparing several student characteristic distributions in each section. No significant differences were found in any of these categories. When the Centra and Non-Centra sections are pooled, the profiles are evenly distributed (Table 3.3).

Analysis of the FCI and VASS data was completed using both the single course and pooled data. This analysis was used in answering questions one and three. Question two will be considered with the discussion board data.

**FCI Data and Research Question 1**

The physics content test consisted of 20 multiple choice questions covering ideas of motion, force and energy from Classical Mechanics that are studied in both physics and physical science. The questions are a subset of the Force Concept Inventory developed by Halloun and Hestenes at the University of Arizona (1996).
The pretest and posttest versions of the test were identical, presented via the BlackBoard testing utility. The students were offered the opportunity to take the tests to earn extra points in their class if they took the test “in earnest,” that is if they completed it thoughtfully. Only two subjects were excluded from the data, and these were due to lack of completion of at least one of the tests. All statistical analysis was performed using the student version of SPSS 13.0.

Cronbach Alpha coefficients were calculated for the FCI data, with pretest and posttest calculated separately. Based on these calculations, for both the pretest and posttest data, question number 20 was excluded from the calculations of both the pretest and posttest, yielding a coefficient value of 0.80 for each test. Student scores were calculated based on the 19 items remaining. This gives a total score possible of 19 points.

A correlation significant at the 0.01 level was found between the pretest and posttest scores (Pearson correlation of 0.49, p < 0.001). This correlation confirmed the use of the pretest score as a covariate to the posttest score. Other factors may be expected to affect the physics posttest scores. The student’s math level has been shown to affect the achievement of students in college physics courses (Meltzer, 2002). Students were classified as being at a prealgebra, college algebra or post algebra level based on the students’ last successful math class or the math placement level if the student had not yet taken a math course. For this data, a significant correlation was found between the physics test scores and math level, with Pearson Chi-squared of 0.027. However, the values could be obtained for only 28 of the 65 students, so this has been excluded from the calculations. Some effect
might also be caused by the student's experience taking college courses or taking online courses. Although correlation coefficients were calculated for each of the other factors such as the number of credits the student had earned, the number of online courses the student had taken, and the student's age and gender, no significant correlation with the physics test scores was found.

Univariate analysis\(^2\) was conducted using the physics pretest as a covariate, and grouping data first by section (four groups) and then by whether the class included Centra or not (two groups). Levene's test for homogeneity had a significance of 0.361 for the full factorial design, so the variances among the groups are not shown to be unequal. The results are tabulated in Table 4.1.

<table>
<thead>
<tr>
<th>Section</th>
<th>N</th>
<th>Posttest Average</th>
<th>Std. Err</th>
<th>p value (LSD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics with Centra</td>
<td>16</td>
<td>5.35*</td>
<td>0.98</td>
<td>0.009</td>
</tr>
<tr>
<td>Physics without Centra</td>
<td>21</td>
<td>9.28*</td>
<td>1.01</td>
<td></td>
</tr>
<tr>
<td>Physical science with Centra</td>
<td>19</td>
<td>7.76*</td>
<td>0.97</td>
<td>0.506</td>
</tr>
<tr>
<td>Physical science without Centra</td>
<td>9</td>
<td>8.84*</td>
<td>1.28</td>
<td></td>
</tr>
</tbody>
</table>

* Covariates appearing in the model are evaluated at Physics Pretest = 6.29.

Table 4.1. Physics Posttest scores for each section

\(^2\) Univariate Analysis was used rather than a 2x2 design due to the limitations of the student version of SPSS. ANCOVA is not available in this version.
These results indicate that the physics section without Centra scored significantly better than the section of physics with Centra. However, the difference was not significant in the physical science class. For both of these courses, the non-Centra section scored better than the Centra section.

A second analysis was conducted looking at the main effect of the use of Centra regardless of course number. Again, the physics pretest score was used as a covariate. For this case, a significant difference was found between the mean physics posttest scores of the two groups. The group without Centra had a higher mean score than the group with Centra. Results are given in Table 4.2 below. According to this model, the use of Centra explained 11.2% of the variance of the data. For this situation, that yielded an observed power of 0.637.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Posttest Average</th>
<th>Std. Err</th>
<th>p-value (LSD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Centra</td>
<td>35</td>
<td>6.56*</td>
<td>0.68</td>
<td>0.023</td>
</tr>
<tr>
<td>Without Centra</td>
<td>30</td>
<td>9.06*</td>
<td>0.81</td>
<td></td>
</tr>
</tbody>
</table>

*Covariates appearing in the model are evaluated at Physics Pretest score = 6.29.

Table 4.2 Physics Posttest scores for each treatment

**Summary of Question 1**

The first research question asked what difference, if any, exists in the level of learning between the students in sections of physics with Centra-based sessions and those sections of physics without. A set of 19 questions from the FCI was used
to measure the level of knowledge in the topics of classical mechanics that were part of the physics and physical science curriculum. A significant difference in mean FCI Posttest score was found between the Centra and the non-Centra groups. This would tend to support the idea that a significant difference exists in the degree of learning between the two groups, with the non-Centra group scoring higher than the Centra group.

**VASS Data and Research Question 3**

The Views about Sciences Survey consists of 39 questions. Of these 39 questions, six concern the student's perception of the class and of the student compared to the class, and ten present two opposing descriptions and ask the student to choose the one most like the student's own viewpoint. The other 23 questions present two extremes and ask the student to judge where the true mix of these two extremes is on the following scale:

1. Mostly a and rarely b
2. More a than b
3. Equally a and b
4. More b than a
5. Mostly b and rarely a

Scoring the students' responses gives a score between 23 and 125. The scores do not indicate that the students answered "correctly" or "incorrectly," but that their answers are aligned or not aligned with the answers given by experts in the
field. A score of 125 is the most aligned. Scores were calculated for each student for both the VASS Pretest and the VASS Posttest.

For the 33 items that contributed to the profile score, reliability tests were conducted for both the VASS pretest data and the VASS posttest data. Cronbach alpha values for each item in each set of data suggested that a more reliable result would be obtained if three questions 35, 36 and 38, were removed from both pretest and posttest, item 18 was removed from the pretest data, and item 25 was removed from the posttest. After removing these, alpha was calculated to be 0.80 for the pretest and 0.81 for the posttest. Comparisons of group means were made for the total score as well as for the reduced score.

A significant correlation was found between the pretest scores and the posttest scores for the full sample of scores, with p < .0005. Details of the correlation calculations are in Table 4.3. Levene's test of homogeneity on the scores were conducted, and both the 33-item score and the 29-item score rejected the null hypothesis of equal variance of error in the posttest (p<.05) between the Centra and non-Centra groups. The VASS posttest scores also showed a significant correlation with the physics pretest score. In this case the assumption of homogeneity of variances was satisfied. The physics pretest score was used as a covariate in the VASS data analysis.

Analyses of variance were conducted using both the full VASS score data and the reduced score data, with the physics pretest score as a covariate. The results are shown in Table 4.4 below. At the p<0.05 level, the difference in mean score was not significant for the 33-item means and the 29-item means.
Summary of Research Question 3

The third research question asked what difference there would be in the epistemological profiles after physics instruction in the two courses for the sections with Centra-based sessions and the sections without. The VASS profile was used to characterize the epistemological beliefs of each student. The students' profiles changed very little over the interval of the study. There was no strong correlation of the VASS posttest scores with the VASS pretest scores. Conducting a multiple regression on the two sets of scores showed that there was no significant difference between the sections of each course using Centra and the sections of each course not using Centra. Furthermore, there was no significant difference found in the mean scores of the combined Centra compared with the mean scores of the combined non-Centra classes.

<table>
<thead>
<tr>
<th></th>
<th>33-item VASS pretest</th>
<th>29-item VASS pretest</th>
<th>Physics pretest</th>
</tr>
</thead>
<tbody>
<tr>
<td>33-item VASS posttest</td>
<td>r = 0.683</td>
<td>r = 0.670</td>
<td>r = 0.556</td>
</tr>
<tr>
<td>29-item VASS posttest</td>
<td>r = 0.635</td>
<td>r = 0.643</td>
<td>r = 0.565</td>
</tr>
</tbody>
</table>

*p <0.005

Table 4.3. Correlation of pretest scores and VASS posttest scores
Table 4.4 VASS posttest scores for each treatment group

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>33-item posttest mean</th>
<th>Std. Err.</th>
<th>p-value</th>
<th>29-item posttest mean</th>
<th>Std. Err.</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Centra</td>
<td>35</td>
<td>75.6</td>
<td>10.1</td>
<td>0.666</td>
<td>6.56</td>
<td>0.68</td>
<td>0.555</td>
</tr>
<tr>
<td>Without Centra</td>
<td>30</td>
<td>74.5</td>
<td>10.2</td>
<td></td>
<td>9.06</td>
<td>0.81</td>
<td></td>
</tr>
</tbody>
</table>

**Discussion Board Data**

General Discussion Board messages were collected for the modules that covered Classical Mechanics in each class. This spanned an interval of five to 6 weeks of the class. The physics Group Discussion Board messages were collected as well as the Laboratory Group Discussion messages from physical science. The number of messages totaled 1023. Individual students ranged from posting no messages to 48 messages. The mean number was 10.5 with a standard deviation of 8.3.

Each message was coded according to the content level and the interaction level as described in Chapter 3. The following gives specific details about how the codes were applied.
Protocol and Logistics Level

Protocol and logistics is the label given to messages about topics other than the physics concepts, assignments or laboratories. Topics might include due dates or class requirements, or involve students getting together in study groups.

The first level of communication was defined as a message that started a thread. Starting a thread is defined as asking a question or making a statement that invited others to respond. This was further divided into three content or types of message. Protocol or logistical questions and statements at this level concerned such things as due dates, location of documents on the website and broken links. The first interaction level for protocol or logistics (labeled as 1a) included questions about due dates or statements about broken links on the website.

Example from a physics student:
I figured out how to make a histogram for the Penny Lab. I couldn’t send it through the regular lab reporting channel because it said I had already completed my lab. So here it is.
Also, is there any way you can possibly make the quizzes available sooner?

The next level of interaction is a response. A response regarding protocol or logistics (coded as 2a) would be an instructor’s or student’s posting that directly answers the question posed. For instance, a student would provide the due date requested or how to locate a resource or link. Example from the physical science instructor:

Initiating message from student (1a):
On module 2 labs, are we supposed to do all 4 or just 2 of them like before?
Response from instructor (2a):

I believe that the document asks you to do all 4 of them but you only need to discuss two of them in the group discussion board. Read it carefully to make sure I am right.

The third and fourth levels of communication involve extending the discussion beyond the response level. The third level was used to indicate that the extension was from a student's comment, while the fourth level indicated that the extension was from an instructor's comment. Examples of these in the content level of protocol or logistics (coded 3a and 4a) include requests for clarification of an answer or a question or statement that refutes an answer.

Example from a physics discussion:

Initiating message from an instructor (1a):

You should be working on posting something in your group work discussion board. You can always come up with your own discussion topics if you don't like the activities I have suggested. The exercises and checkpoints in your book can usually give you some ideas.

Response from a student (2a):

Come on Group C. I've posted in group work for module 3. Somebody needs to respond.

Extension posted by a student to a student (3a)

We will, it hasn't even been a full day since you posted the group work. I just started doing the extra labs.

The dividing lines became difficult to establish between level 3 and level 4. In the above example, it isn't clear from the text that the student (the third quote) is responding to the instructor's original message or to the student's message. When that is the case, the thread structure of the discussion determined the coding. In this
case the statement was coded as though the student “replied” to the first student’s response to the instructor, not to the instructor herself. Therefore this message was coded as an extension to a student’s posting. If the same message had been posted as a response to the instructor, as evidenced by the order of posting in the thread structure, then it would have been coded “2a,” a response regarding protocol or logistics. These distinctions will be considered in the analysis section as well.

Another difficult type of message was a response to a response that did NOT further the discussion. In this case, the message was coded as level 2. An example of this would be a student saying thanks or acknowledging the answer given. The goal of the coding was to establish whether the students were going deeper into a subject. Coding a message at level three or four would indicate that the author was leaving the discussion still open. Coding the message at level two would indicate that the author was simply responding to, but not furthering, the discussion.

Example from a physical science student:

**Initiating question from first student (1a):**

*I started to do the practice pages for Chap 8 but, I couldn’t find where they got the calorie amounts for turning ice into liquid etc... Did I miss something in the reading?*

**Response from second student (2a):**

*Page 197 ‘Figuring physical science’*

**Response to the second student by the first student (2a):**

*Thanks*
**Factual Content Level**

In this level of content, messages contained questions or statements that give information, whether correct or incorrect, dealing with a phenomenon, but that didn’t allude to the underlying principles (whether correct or incorrect) involved. This group of messages is labeled with a “b” and is further subdivided by interaction level as discussed in the section about protocol and logistics.

The first interaction level in this content area (1b) would be an initial posting asking a question or making a statement about an exercise or problem they were working on. To be in the Factual Content level, the student would ask the question without referring to the underlying physics or overarching concepts involved. This could be interpreted as the student wanting to know the answer but not necessarily looking for any deep learning in this issue.

Example from physical science student:

*Initiating student (1b):*

*IM having a terrible time figuring out all of this math. Can anyone explain where the formulas are and how to work them. Any help would be greatly appreciated*

Level 2b labeled a response containing factual content or responding to a factual question (such as a yes or no question). The message kept the discussion at the factual level without exploring the conceptual basis for the response.

Example from a physical science student:

*Response to a question (coded as 2b):*
I found the answer to this question; in case anyone else is still waiting for an answer, it is in section 5.2 (chapter 5).

3b and 4b messages extended the discussion from a response but kept the discussion at a factual level, not discussing the underlying principles involved. Examples of each of these follow.

Example from physical science:

**Student 1 (1b):**

*IM having a terrible time figuring out all of this math. Can anyone explain where the formulas are and how to work them. Any help would be greatly appreciated*

**Instructor response (2b):**

*If you would be more specific as to which problems, I would be happy to help. Also, I will be on Centra today around 2:30 this afternoon. If you have questions either login to Centra or let me know here and I can try to address them and then you can view it later.*

**From student 1 again (4b):**

*Sorry I forgot to mention. I'm having a hard time with trying to work out the word problems in chapter 4 which are mostly about universal gravity.*

**From student 2 (3b):**

*If you are talking about pages 95-96 of the text, I don't get that either. Please tell me that all we need to know is that G is a known quantity.*

Some laboratory-related messages bordered between a logistics topic and a factual content topic. Many of the laboratories required some adaptation to be completed in the students' homes with the materials they had. Without a laboratory group present, students didn't have the ideas and experiences of others to help as they performed the activities. When a student asked for help on how to do a step in
the laboratory, this was coded as factual content. Such messages were primarily logistical (how to) in nature, but they were about the logistics of a science process, not about how to access a resource or how to submit a paper. The process was part of the content of the class.

An example from physics:

Student 1 (coded as 1b)
Hey I can't get to the optional website to see these pictures and I suck at trying to spin them can anyone help

Student 2 (coded as 2b)
Put them on a pencil, then stick the pencil into a drill and spin it around

Student 3 (coded as 3b)
Yeah; j. tape it to a cd; than open any of ur cd players; do one of 3 things
If its open faced
1 start and stop to watch it; 2 if its closed it will be more tricky; and/or 3 just leave the lid open and spin it manually w/ur hand; softly as to not break anything!

Conceptual Content Level

In this content level, the discussion was delving into the ideas and underlying principles involved in the material. This level was labeled with a c. The four interaction levels were assigned as in the previous categories. A message that asked a question or started a discussion about applying a general principle or asking why an exercise answer is right was coded as 1c. Responses and extensions to messages that kept the discussion at this level were coded 2c, 3c and 4c. Some responses or extensions compared the situation given in class to an event outside. This shows that the student is going beyond just getting the answer right, and so it
was coded at the conceptual level as well. An example conversation is shown below.

Example from physics:

**Student 1 (1c):**

*Today I was working on the homework for chapter 13 about liquids and on question 30 about the barge filled with scrap iron. I was having a hard time figuring out what would happen if the iron was thrown over board whether or not the water level in the lock would rise, fall or stay the same. Sooo, I did a little experiment in my kitchen floating a plastic cup inside a large measuring cup. I put a few pennies and the jiggler to my pressure cooker (it’s a pretty heavy little thing) into the plastic cup. The water level was right at the 8 cup mark and the cup with all its “cargo” was floating. Then I took the jiggler out put it into the water and guess what happened. Did the water level rise, fall or stay the same? I got my answer to questions #30.*

**Student 2 (2c):**

*The water level will fall. This is because the iron will displace a greater amount of water while being supported than when submerged. A floating object displaces its weight of water, which is more than its own volume, while a submerged object displaces only its volume. It is pretty crazy to think about!* 

**Student 1 (3c):**

*That’s exactly what happened. Nothing like seeing something actually happen to really “grok” it.*

Some conversations had mixed levels, so that the first message may be coded as a "b" with a response coded as a "c". The messages were coded independently. From physics:

**Student 1 (1b):**

*I’m not sure if there’s something special that’s supposed to happen; when I lift my finger off of the straw, the water drains out. Anyone get a different result?*
Students 2 (2c):

I use this method with water at restaurants to get napkins wet to wipe off the kids' hands.

The exception to this independence was a message essentially closing the discussion. In this case, even if the message was the third or later message, it was a simple response, not an extension to the conversation, so it was coded as an interaction level 2. Then the content level was assigned based on the previous message.

Example from physics:

Student 1 (1b):

On project #3, I understand the concept, but how are you pouring air from one into the other when the other is already full of air?

Response from student 2 (2b):

I think you need to let one fill in with water.

Closing remark from student 1 (2b):

Thanks...that makes more sense.

After all of the messages were coded, the number of each student's posting of each level was recorded and then analyzed for trends. Various analyses were conducted including distributions in each class of different message types, comparisons of total postings of each type in each class, and consideration of outliers. These specific analyses are given in detail in the following chapter.

All of the coding used in the analysis was conducted by the researcher. In addition, two other online instructors from the same college were asked to code a
subset of the data. Each of these coded 100 messages and results were compared with the researcher’s coded results. Interrater reliability was calculated to be 83%.

Activity on the Discussion Boards

The number of participants in the discussion board data was fairly equal among the sections. A total of 97 participated, 48 from the physics and 49 from physical science. The Centra/non-Centra groups were also fairly even, with the Centra group having 50 and the non-Centra group 47. A student was included in the data if the student either made at least one posting or completed the assessments included in the quantitative data. There were two students, both in the physical science Centra group, who did not post any messages but who completed the assessments.

A summary of the data set is pictured in Figure 4.1. The broad distribution illustrates that the categories are able to differentiate among the types of messages posted. The fourth interaction level (extensions from an instructor’s response) was not well populated. Since both the third and fourth levels were extensions of a thread (either to a student’s or instructor’s response) these two categories were combined in much of the analysis.
Total Number of Messages of Each Type

Figure 4.1. Number of student messages of each category
Combining all interaction levels of each content level (Figure 4.2) shows that the highest number of messages overall fell into the conceptual level.

This study concerns differences in the discussion patterns between the Centra and the non-Centra groups. As a first comparison, a distribution of messages in each group is shown in Figure 4.3. The bars that are toward the right in each group represent the initiating messages while the bars on the right represent extensions to responses.

The content levels a, b and c identified the distribution of message topics posted by the students. The content levels b and c indicate discussion about learning physics. Level a messages are concerned with protocol and logistical issues. Figure 4.4 shows the distribution of message in each content level by course. The bars represent the Centra and non-Centra sections of each course.

From all of these considerations, no clear trend can be seen. Comparing the Centra and non-Centra sections in physics shows more messages tended to involve level c topics, but the same comparison in physical science shows the opposite.

Figure 4.2. Total number of student messages in each content level
Figure 4.3. Distribution of each category of messages by group.
Figure 4.4. Number of student messages of each content level
Activity of Participants

Looking at the messages section by section revealed that a large number of messages were posted by one or two students. While showing a high volume of messages, it is possible that such discussions involve relatively few students directly. To investigate this, an activity level was assigned to each student based on
the number of messages that student posted. To define cutoff points for this Activity Level scale, the amount of interaction expected in the course was considered along with the distribution of activity of the students themselves. Each student was to post at least three messages for each of three modules in both courses. Nine messages would thus be the least number of postings to get full credit in the discussion part of the course. The students actually had numbers from 0 to 48 messages, but there were few students who posted more than about 35 messages. Specific distributions are shown in Figure 4.6.

From this information, the levels of interaction were established as shown in Table 4.7. Figure 4.7 compares the number of students in each activity level in the Centra versus non-Centra classes. The chart shows very similar profiles between the two groups. There is a small shift from “Required” to “Minimal” participation with the addition of Centra. However, this shift is not seen in the courses individually. Figure 4.8 shows the distribution broken down by course. In this case, very little difference is seen comparing Centra and non-Centra sections of the same course.

<table>
<thead>
<tr>
<th>Activity Level</th>
<th>Number of Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>1 - 6</td>
</tr>
<tr>
<td>Minimal</td>
<td>7 - 12</td>
</tr>
<tr>
<td>Frequent</td>
<td>13 - 30</td>
</tr>
<tr>
<td>Very Frequent</td>
<td>31 and up</td>
</tr>
</tbody>
</table>

Table 4.7. Definition of Activity Level of students
Figure 4.6. Histogram of the number of students in each section posting a given number of messages.
The communication that is most critical to the learning process concerned with the ideas of the content, not on the nuts and bolts of getting the course completed. Centra sessions were introduced in an attempt to add a forum for real-time exchange of ideas similar to what is experienced face to face in a classroom setting. These sessions could possibly replace conceptual asynchronous online discussions, or possibly supplement them. Figure 4.9 displays the number of students in each course, grouped by the number of messages. The histogram bins label the number of messages the students posted. Centra and non-Centra sections are compared.
Figure 4.7. Number of students in each participation level
Student Activity Levels in Centra and Non-Centra Sections

Shown by Course

Figure 4.8. Student participation by course, comparing Centra and non-Centra sections
Figure 4.9. Number of students in each course grouped by number of conceptual messages posted and by Centra access

Finally, in Figures 4.10 through 4.13 the number of messages posted by each student is given separated by the participation level of the student. Each course is shown in a different figure.

**Summary of Research Sub Question 2**

In this study, introducing this alternative, more personal, mode of communication into the virtual classroom environment did not clearly change any pattern of posting on the course discussion boards. Considering all of the points
made above, no clear change in frequency or type of interaction can be determined due to the use or non-use of Centra for virtual class sessions.

Figures 4.10. Physics message distribution by participation level of student
Figures 4.11. Physics message distribution by participation level of student
Figures 4.12. Physical science message distribution by participation level of student
Figures 4.13. Physical science message distribution by participation level of student
CHAPTER FIVE: DISCUSSION

Summary of Results

The purpose of this study is to understand the effects of using interactive software tools on the physics learning of the students, the amount of change in students’ epistemological profile, and differences in frequency and content of course discussion board interactions. For the students in this study, there was a significant difference in physics learning between the students with access to Centra and those without, with the Centra students performing better than the non-Centra students. However, no significant difference was seen in the epistemological change between the groups in the study. The patterns in the discussion board showed several interesting features, but no clear trend in the content of the postings was seen between the Centra and the non-Centra groups. The only significant (p< 0.05 level) differences observed were the number of level 2b and level 2c messages posted. In this case the Centra students posted significantly more in each of these categories than the non-Centra students. From these results, evidence exists that the use of Centra for weekly class sessions and instructor office hours did affect the physics learning in these two courses. Some differences existed in the online discussion, but this data did not reveal a clear trend that favored one group over another.

Some interesting features of the data were not revealed in the above comparisons, but may shed light on the underlying structure of influence that the use of Centra had on these courses. The following sections reflect on these features.
Actual Use of Centra

The addition of Centra to the two courses had little positive effect on the students’ learning, epistemological perspective, or interaction on discussion boards. Centra provides a real-time, pseudo-face-to-face experience for students, and was available to students at times the students had indicated would be useful for them. All sections were led by instructors who place high value on student/instructor and student/student communications in their classes. Each had used Centra in online courses over the past year to conduct classroom discussions. So what actually happened in the Centra study classes?

Reduced to Lecture

Both of the instructors involved in the study place a high value on discussion between students and students with the instructor for the best learning experience in their respective physics classes. In keeping with this emphasis, both instructors presented the Centra class sessions as a chance to discuss the material and to help students figure out what they are reading and learning on their own. However, students came into the session expecting to take notes from a lecture, and expecting not to participate much beyond the agreement, question and laughter emoticons offered by Centra. By the end of the semester, the class sessions did indeed become more lecture-based than discussion-based in spite of the stated intentions of the instructors. Why was this? Several things could account for this shift in pedagogy.
First, although the instructors had taught via Centra for several semesters, the technology was new to the students in the class. They were enrolled in physics, which is already perceived as a difficult course and is worth five credits on their transcripts. Although most students did have a microphone and speakers already connected to the computer they were using, attending a virtual class with these tools was still a new experience. Students, especially distance students who tend to be very busy with many responsibilities, may have opted not to participate due to the learning associated with the Centra system itself. This idea is supported by cognitive load theory. Cognitive load theory looks at learning in terms of processing or creating schemata in long term memory (Kirschner, 2002). Working memory is used to do the processing and has a limited capacity. If a person is trying to work with new elements, there is a limit to how many can be processed successfully. In this case, with students in a new class which is perceived as difficult, conducted online, and with audio and video computer peripherals needed for the “class” session, this may be above the limit of many students. If the sum cognitive load is above the capacity of working memory the students will struggle. To compensate, students will choose what they find expedient. In this case, expedience could be observing the class session without participating in the discussions or interacting with the others in the session.

Anderson wrote about the "hidden curriculum" (Anderson, 2001) in web-based classes. Students today need to learn the technology before they can learn what is considered the content of the course. They need to learn how to work with the instructional platform using their particular computer and technology
components. To communicate at a basic level in an online course, distance students need to learn how to upload and download, fax, use email and messaging whereas traditional students are able to communicate using familiar skills of interaction practiced during years of K-12 schooling. Using familiar skills does not add to the students’ cognitive load. Until using other technologies becomes natural, this technology barrier will continue to be an issue in distance education.

**Lack of Attendance**

One instructor states that she had no more than two students in a Centra class session in real time, and many sessions had no one present other than the instructor. The second instructor states that she had between one and twelve students (out of 28 initially enrolled) sign in to Centra for class session. Neither instructor had students participate in the office hours. The class sessions were recorded and posted online for students to review. These recordings, however, were accessed by many students in both classes. What does this mean?

Lack of attendance on an occasional basis is not unusual for regular classes due to other requirements in the students’ lives such as work schedules, family demands and emergencies. The students were not “required” to attend the Centra class sessions, but sessions were scheduled on two days and at two times such that the students agreed they would be able to attend.

According to Anderson (Anderson, 2002), student/instructor interactions are perceived to have the highest value to students. One may conclude from this finding
that more students would be seen participating in the Centra classes, but this was not the case. If this interaction is the most important to the students, then it could be that the Centra classes were not perceived as student/instructor interactions. The students might have perceived the same lack of intimacy that was found in ITV studies (Anderson et al., 2002; Anderson & Kent, 2002). This is consistent with Taylor and Maor’s "anomaly of interactivity," students expressed a high need for community, but they did not take advantage of the opportunity to connect with peers via the class discussion board, choosing instead to post "monologue" messages rather than "dialogue."

Another explanation could be that these particular students didn’t want the interaction as much as they needed it to be asynchronous. This is consistent with Rovai’s research comparing the needs for community between an asynchronous distance class and a face to face class. He concluded that the distance students were satisfied with less interaction (Rovai, 2002). One student in the physics Centra class had attended sessions early on, but missed some later sessions. He stated that that he was not having problems with that material so he didn’t need to participate. This thought pattern is indicative of the independence and different needs of online students seen in Rovai’s study.

A student’s “needs” depend on the goal of taking the class. If the student is able to complete the class, complete the required work and pass the required tests, which may well be a “successful” school experience in the student’s view. On the other hand, to the instructor the experience is successful if the student has learned to think differently, more scientifically, and to experience the world differently, able to
analyze physical phenomena in the student's world, as a result of taking this class. The student may not value this goal, seeing the passing grade as sufficient, without experiencing deep learning or changing their world view. The lack of deep learning may not be critical to the student (even if it is perceived) compared to the gain of convenience by not interacting within the class.

**Real-time Participation versus Viewing a Recording**

Since the class sessions were recorded and made available to the rest of the class, the students may see attendance during the Centra class session as expendable. As one student stated in physics, "It would be better if I was there during the Centra session, but I can still see if I missed anything." And by viewing the recording, the student is using technology that is already familiar thereby gaining some of the same benefits without the additional cognitive load.

Determining whether to participate in real time or to view later is part of another hidden curriculum, the curriculum of learning how to learn. Students studying at a distance make choices about how and when to engage in the course, and their goals may be very different from the instructor's goals for them. In traditional classes, students know they should be in class several times a week, and there is direct guidance as to what the student should do between classes. This guidance is often a natural result of common talk in the classroom. Distance students need to know at the beginning of the semester how to "do school" in a distance mode, and even if instructors are very clear about what to do, students
need to know to and know how to access that information. For classes such as Centra, the students need to be able to see the benefits of participation and to value those benefits as helpful to their learning.

In summary, although Centra was available to the students, fewer than half of the class chose to participate in it in real time. For whatever reasons, the majority of the students did not value that experience enough to participate regularly. Increasing the participation level requires the instructor to be more active and purposeful in directing the student. It requires the student to be more comfortable and skillful with the technology. And it requires that the experience during the virtual class be and be perceived as valuable and critical in the student’s education.

**Equivalency of Interactions**

Anderson’s Theory of Equivalence of Interactions predicts that as long as deep levels of at least one form of communication is used during the learning process, use of other forms may be lessened or completely ignored (Anderson, 2002). In terms of equivalency, this study is considering whether or not virtual class sessions via Centra were equivalent with discussion board communication. The question of whether either one of these is equivalent to face-to-face interaction was not directly addressed in this study. When examining activity on the class discussion boards, the Centra classes had a significantly lower mean number of levels b and c messages posted than the non-Centra classes. This would support the equivalency, although this is not the only possible explanation for the difference.
Level a messages were more frequent in the Centra classes than the non-Centra classes. Level a indicated a logistics or protocol message, and a high level of messages in this area could also indicate the extra time and skill needed to participate in the Centra sessions.

In his work Anderson referred to three forms of communication for students: student/student, student/instructor, and student/content. In the area of educational technology, however, there are different ways of viewing the last interaction, student/content. For example, when a student views a video tape of the instructor's class session, which type of interaction is it? Since the instructor cannot react in this interaction, then it is probably not student/instructor. Hassenplug and Harnish, however, suggest that some interaction can be experienced vicariously and still provide the cognitive and affective benefits of overt interaction (Hassenplug & Harnish, 1998). How would the student view it? Would this count as interaction with the instructor in the student's view? Hassenplug and Harnish conclude that for the student to be satisfied with the experience, it is the perception of interaction rather than the actual amount of interaction that matters. In agreement with this, Anderson encourages distance instructors to move student/instructor interactions to student/content interactions, such as video lecture or FAQ's as a way to manage the increased time demanded of distance faculty. Even so, to answer the question as to the equivalency of a taped class session or even a virtual class session to a face to face class, one must consider not just the student's perception of community but also the impact on the student's learning. This comparison is beyond the scope of this study.
Epistemological Profiles

The VASS survey in several formats has been used for many years. Research on students' epistemologies using this instrument have shown that students do not change their profile significantly over the course of their education, citing the evidence that high school student profiles are very similar to college student profiles.

In this group of students, in general, little change occurred in profile from the beginning of the course to the midpoint. However the changes that were seen indicate that the students epistemological profile score actually went down while they were studying physics. The average change was 12 points on the 125-point ordinal scale. Although this was not a significant change, it is interesting to consider that there is no increase in VASS score, which would indicate that taking these courses moved the students to think more like scientists do.

This may be due to the individual items as they relate to the course itself. For instance one of the VASS questions asks students the following.

In physics, mathematical formulas: (1) express meaningful relationships among variables; (2) provide ways to get numerical answers to problems.

For a student in the middle of the course, it is clear that the formulas do in fact provide ways to get numerical answers to problems, even though the expert view would be that they express meaningful relationships. The student is working for a grade, and this may affect the answer more than it might either before or after the student is in the class. It is possible that the theoretical and factual content overshadowed the scientific processes and nature of science content. Nature of
Science education research points to the need for explicit instruction of how science is done and how science is learned (McComas et al., 1998). Laboratories are a logical forum for active learning about science processes. However the online classes had laboratory activities completed individually without immediate discussion about what the student was doing and observing. Increasing the discussion of the nature of science should result in better understanding of the process and content of science (McComas et al., 1998).

**FCI Overall Scores**

The data from the FCI tests did show that the Centra classes averaged lower on mechanics learning than the non-Centra classes. The difference in scores between the physics and the physical science sections is probably due to the fact that physics covered only classical physics, while physical science included chemistry and earth and space science as well. Thus the depth of learning in the physical science course is expected to be less than in the physics course. Taking that into account, however, it appears that the addition of the Centra class sessions impacted the students’ learning negatively.

Again raising this question of equivalency, it appears that in this case, adding either the live Centra classes or the taped Centra classes or both, although reducing the amount of discussion as predicted, did not support content learning at the same level. Examining the scores of individual students and their rate of attendance at the live sessions could help in understanding these effects.
Limitations of This Study

The results of this study can inform educators as they design their own courses. The traits of the participant group limit the study results, however. The students were urban and suburban community college students, most of whom did not have the means, whether physical, financial, motivational or logistical, to attend class in a traditional setting. This affects many aspects of the study, such as the value placed on asynchronous interaction or the independent nature of the student.

Another issue is self-selection. The physics course was listed in the enrollment materials as Online. No mention was made of using or not using Centra as a part of the class. The physical science class, however, was listed as Online, and in addition the description included the fact that the course may use microphones and cameras with Centra to conduct weekly class sessions. In both physics and physical science, students did not select which section (Centra or non-Centra) they would be in. This allowed more random grouping in the study design. Had the students known, however, the results could have been very different. If students choose this mode of instruction, they probably would perform better (Collins & Pascarella, 2003).

Both classes were in the Physics Department. The department has a history of being taught and learned in specific ways, ways that are different from social sciences or humanities classes. Students traditionally do not expect physics to be interactive and discussion-based, and do expect a certain amount of lecture. This discrepancy between the student’s expectations and the actual activities of the class
may be difficult to negotiate at first. Instructor guidance may need to be more explicit about this discrepancy so students have a better chance to accommodate the new ideas.

Finally, as students become more adept at using technology, this mode of instruction may become more natural. If so, signs of intimacy and support may be expressed and correctly interpreted more frequently. Both of these factors could shift the results of this study.

**Equivalence Revisited**

Anderson’s Theory of Equivalence of Interaction suggests that there is a “conservation of interaction,” where the total amount of interaction needed for learning a concept is constant but can be transformed from one type to another. He encourages faculty to transform student interactions with their instructor to student interactions with content, whether textbook or streaming video or another medium. This makes the instructor’s goal to automate the process of education to the point of least personal interaction. When one type of communication is introduced another type may be used less, but is this a good thing? Shouldn’t the instructor’s goal be to increase the amount of interaction the student has with the class and instructor? If interaction is indeed critical to the student’s learning, then wouldn’t it be better to introduce the synchronous sessions with the purpose of *increasing* the discussion board activity?
An oncampus class session can be replaced by a computer mediated session with audio video capabilities. This in turn can be transformed into a recorded computer mediated class session. This interaction is only interaction by the lowest limit if interaction requires that both interacting entities be affected by the event. The student is affected to the extent that the student views the recording, possibly engaging with the concepts presented. The student affects the tape to the extent that the tape is viewed, fast-forwarded, rewound and replayed. The recording cannot respond intelligently to the student, but can only play, fast-forward, rewind and replay in reaction to the student’s actions. This is not what Dewey meant as interaction in the sense of a transaction. This study supports the idea that the virtual synchronous discussion and the asynchronous discussion board discussions are not equivalent—they did not support learning at the same level. The idea of such equivalence simplifies the complex process of learning to a transfer of information, going against current learning theory and the importance of the social environment in learning, and in fact what constitutes learning. From this study it appears that changing the medium of communication or interaction changes the nature of the learning that occurs.

**The Future of the Community College**

The inherent flaw in online education is that students cannot be expected to know what it means to learn in a certain content area, how to make good choices of how to learn, or that they have in fact really learned anything. Students will most
likely choose what is expedient. If a successful learning experience is measured by
the students’ satisfaction with it, successful learning is equivalent to the expedience
in taking the course, not to the change in the way the student thinks about the world
and science.

What does this mean for the community college? The community college
culture is largely a consumer culture, where students are the consumers or clients,
and education is the product or service. At the same time the community college
has as its mission to serve the educational needs of the community members. A
great number of options exist for students to get easy credits. If students return to
programs that are satisfactory to them, the programs that allow for expedience will
be popular. If a community college enters the competition for students, the issue of
expedience is important, or the college will lose students. Without students there is
no college. Can faculty be educators as well as certificate brokers?

The proliferation of distance classes has exponentially increased the
community college’s marketplace characteristics. Schools from several other states
and countries have virtual campuses in urban areas that cater to the student market.
Local colleges either enter that competition or suffer from lack of students.
Prestigious schools such as Northwestern University take pride in not offering any
online courses. Many courses are supported by the same courseware, but the
student/instructor face-to-face communication in the classroom is not sacrificed. For
a community college, maintaining a similar standard could be the downfall of the
school.
If distance instruction is “necessary,” educators must have the pedagogical and technical tools needed to make the experience result in distance learning. Can virtual classroom software be used effectively? Research is needed that focuses on what is actually occurring during the session, both for the student and the instructor. In addition, how do students perceive the activity? Do students really view an oncampus class session, a virtual class session and a recording of the class session as equivalent enough? What strategies can instructors use to enable true communication, if possible, over a distance? How can educators convince students that an education is more than a list of the names of courses that they have endured?

The task is daunting at the least: To create educational experiences at a distance that result in learning, to continue to enroll students in these experiences, and to do so within the technological and budgetary constraints in place today.

**Conclusion**

This study shows that there probably is some impact on the discussion board interactions when virtual class sessions are introduced into the curriculum. There was also an associated decrease in achievement on the physics content exam with the addition of the virtual class sessions.

The study also highlights some issues that ought to be considered when designing future courses. Careful consideration should be given to the amount of additional skill or access required when making use of this type of medium so that
the experience adds to the engagement of the learner in the real content of the
course. Perhaps offering a course integrating computer applications and the content
area would allow the student to gain the skills needed to use new technology without
detracting from the importance of learning the content of the integrated course.
Instructors should also think carefully about the goals of introducing various
interaction components and how they will impact the other components of the
course.

Finally, this study has illustrated the dilemma facing community college
educators today. Is it possible to offer distance programs that are effective in
educating their students?
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APPENDIX A

Views about Science Survey

1. By comparison to the rest of the class, how well can you understand the material presented in your current textbook when you read it on your own?
   a. Excellent
   b. Good
   c. Average
   d. Weak
   e. Extremely poor

2. By comparison to the rest of the class, how good are you in solving physics homework problems on your own?
   a. Excellent
   b. Good
   c. Average
   d. Weak
   e. Extremely poor

3. By comparison to the rest of the class, how well do you normally do in your current physics course exams?
   a. Excellent
   b. Good
   c. Average
   d. Weak
   e. Extremely poor

4. How often do you read about science in newspapers, magazines, or books other than your current school textbooks?
   a. More than once a week
   b. About once a week
   c. About once a month
   d. Seldom
   e. Never

5. How often do you watch science documentaries on TV?
   a. More than once a week
   b. About once a week
   c. About once a month
   d. Seldom
   e. Never

6. For me, reading my physics textbook is often:
   a. An enjoyable experience
   b. A frustrating experience

7. If I had a choice:
   a. I would never take any physics course
   b. I would still take physics for my own benefit
8. If we want to apply a method used for solving one physics problem to another problem, the objects involved in the two problems must be:
   a. Identical in all respects
   b. Similar in some respects

9. Different branches of physics, like mechanics and electricity:
   a. Are related to each other by common principles
   b. Are separate and independent of each other

10. Knowledge of chemistry is:
    a. Related to knowledge in physics
    b. Independent of knowledge in physics

11. Physicists say that electrons and protons exist in an atom because:
    a. They have seen these particles in their actual form with some instruments
    b. They have made observations that can be explained by such particles

12. Physicists' current ideas about particles that make up the atom apply to:
    a. Physical objects that could be anywhere in the universe
    b. Some physical objects in the universe but not others

13. Newton's laws of motion (like his second law expressed in the form of \( F = ma \)) apply to:
    a. Physical objects that could be anywhere in the universe
    b. Some physical objects in the universe but not others

14. Physicists' current ideas about particles that make up the atom:
    a. Will always be maintained as they are
    b. May eventually be modified in some respects

15. Newton's laws of motion:
    a. Will always be used in their present form
    b. May eventually be modified in some respects

16. Learning physics requires: (1) a serious effort; (2) a special talent.
    a. Mostly (1) and rarely (2)
    b. More (1) than (2)
    c. Equally (1) and (2)
    d. More (2) than (1)
    e. Mostly (2) and rarely (1)

17. I study physics: (1) to satisfy course requirements; (2) to learn useful knowledge.
    a. Mostly (1) and rarely (2)
    b. More (1) than (2)
    c. Equally (1) and (2)
    d. More (2) than (1)
    e. Mostly (2) and rarely (1)
18. Reasoning skills that are taught in physics courses can be helpful to me: (1) in my everyday life; (2) if I were to become a scientist.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

19. My score on physics exams is a measure of how well: (1) I understand the covered material; (2) I can recall by rote things done by the teacher or in some course materials.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

20. For me, doing well in physics courses depend on: (1) how much I put into studying; (2) how well the teacher explains things in class.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

21. In my opinion, for any question asked in class, a good physics teacher should be able to: (1) provide the correct answer; (2) show how or where one may get the answer.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

22. When I experience a difficulty while studying physics: (1) I seek help or give up trying; (2) I try to figure it out on my own.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

23. When studying physics in a textbook or in course materials: (1) I find the important information and memorize the way it is presented; (2) I organize the material in my own way so that I can understand it.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)
24. For me, the relationship of physics courses to everyday life is: (1) easy to recognize; (2) hard to recognize.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

25. In physics, it is important for me to: (1) memorize technical terms and mathematical formulas; (2) learn ways to organize information and use it.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

26. In physics, mathematical formulas: (1) express meaningful relationships among variables; (2) provide ways to get numerical answers to problems.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

27. After I go through a physics text or course materials and feel I understand them: (1) I can solve related problems; (2) I have difficulty solving related problems.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

28. The first thing I do when solving a physics problem is: (1) represent the situation with sketches and drawings; (2) search for formulas that relate to given unknowns.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

29. In order to solve a physics problem, I need to: (1) have seen the solution to a similar problem before; (2) know how to apply general problem solving techniques.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)
30. For me, solving a physics problem more than one way: (1) is a waste of time; (2) helps develop my reasoning skills.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

31. After I have answered all the questions in a physics homework problem: (1) I stop working on the problem; (2) I check my answers and the way I obtained them.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

32. After the teacher solves a physics problem for which I got a wrong solution: (1) I discard my solution and learn the one presented by the teacher; (2) I try to figure out how the teacher’s solution differs from mine.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

33. How well I do on physics exams depends on how well I can: (1) recall material the way it was presented in class; (2) solve problems that are somewhat different than what I have seen before.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

34. To me, physics is important as a source of: (1) factual information about the natural world; (2) ways of thinking about the natural world.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

35. The laws of physics are: (1) inherent in the nature if things and independent on how humans think; (2) invented by physicists to organize their knowledge about the natural world.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)
36. The laws of physics portray the real world: (1) exactly the way it is; (2) by approximation.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

37. Physicists use mathematics as: (1) a tool for analyzing and communicating their ideas; (2) a
   source of factual knowledge about the natural world.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

38. Scientific findings about the natural world are: (1) dependent on current scientific knowledge; (2)
   accidental, depending on the scientists’ luck.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)

39. I answered the questions in this survey: (1) to the best of my ability; (2) without thinking seriously
   about them.
   a. Mostly (1) and rarely (2)
   b. More (1) than (2)
   c. Equally (1) and (2)
   d. More (2) than (1)
   e. Mostly (2) and rarely (1)
APPENDIX B

**Force Concept Inventory**

1. Two metal balls are the same size but one weighs twice as much as the other. The balls are dropped from the roof of a single story building at the same instant of time. The time it takes the balls to reach the ground below will be:
   A. About half as long for the heavier ball as for the lighter one.
   B. About half as long for the lighter ball as for the heavier one.
   C. About the same for both balls.
   D. Considerably less for the heavier ball, but not necessarily half as long.
   E. Considerably less for the lighter ball, but not necessarily half as long.

2. Two metal balls are the same size but one weighs twice as much as the other. The balls roll off a horizontal table with the same speed. In this situation:
   A. Both balls hit the floor at approximately the same horizontal distance from the base of the table.
   B. The heavier ball hits the floor at about half the horizontal distance from the table than does the lighter ball.
   C. The lighter ball hits the floor at about half the horizontal distance from the table than does the heavier ball.
   D. The heavier ball hits the floor considerably closer to the base of the table than the lighter ball, but not necessarily at half the horizontal distance.
   E. The lighter ball hits the floor considerably closer to the base of the table than the heavier ball, but not necessarily at half the horizontal distance.

3. A stone dropped from the roof of a single story building to the surface of the earth:
   A. Reaches a maximum speed quite soon after release and then falls at a constant speed thereafter.
   B. Speeds up as it falls because the gravitational attraction gets considerably stronger as the stone gets closer to the earth.
   C. Speeds up because of an almost constant force of gravity acting upon it.
   D. Falls because of the natural tendency of all objects to rest on the earth’s surface.
   E. Falls because the combined effects of the force of gravity pushing it downward and the force of air pushing it downward.

4. A large truck collides head-on with a small compact car. During the collision:
   A. The truck exerts a greater amount of force on the car as the car exerts on the truck.
   B. The car exerts a greater amount of force on the truck as the truck exerts on the car.
   C. Neither exerts a force on the other, the car gets smashed simply because it gets in the way of the truck.
   D. The truck exerts a force on the car but the car does not exert a force on the truck.
   E. The truck exerts the same amount of force on the car as the car exerts on the truck.
5. A steel ball is attached to a string and is swung in a circular path in a horizontal plane as illustrated in the accompanying figure. At the point “P” indicated in the figure, the string suddenly breaks near the ball. If these events are observed from directly above as in the figure, which path would the ball most closely follow after the string breaks?

A. A  
B. B  
C. C  
D. D  
E. E

6. The figure depicts a hockey puck sliding with constant speed $v_0$ in a straight line from point “a” to point “b” on a frictionless horizontal surface. Forces exerted by the air are negligible. You are looking down at the puck. When the puck reaches point “b”, it receives a swift horizontal kick in the direction of the heavy print arrow. Had the puck been at rest at point “b”, then the kick would have set the puck in horizontal motion with a speed $v_k$ in the direction of the kick. Which of the paths below would the puck most closely follow after receiving the kick?

A. A  
B. B  
C. C  
D. D  
E. E

7. The figure depicts a hockey puck sliding with constant speed $v_0$ in a straight line from point “a” to point “b” on a frictionless horizontal surface. Forces exerted by the air are negligible. You are looking down at the puck. When the puck reaches point “b”, it receives a swift horizontal kick in the direction of the heavy print arrow. Had the puck been at rest at point “b”, then the kick would have set the puck in horizontal motion with a speed $v_k$ in the direction of the kick. The speed of the puck just after it receives the kick is:

A. Equal to the speed $v_0$ it had just before the kick.  
B. Equal to the speed $v_k$ resulting from the kick and independent of speed $v_0$.  
C. Equal to the arithmetic sum of speeds $v_0$ and $v_k$.  
D. Smaller than either of the speeds $v_0$ or $v_k$.  
E. Greater than either of the speeds $v_0$ or $v_k$, but less than the arithmetic sum of these two speeds.

8. The figure depicts a hockey puck sliding with constant speed $v_0$ in a straight line from point “a” to point “b” on a frictionless horizontal surface. Forces exerted by the air are negligible. You are looking down at the puck. When the puck reaches point “b”, it receives a swift horizontal kick in the direction of the heavy print arrow. Had the puck been at rest at point “b”, then the kick would have set the puck in horizontal motion with a speed $v_k$ in the direction of the kick. The speed of the puck after receiving the kick:

A. Is constant.  
B. Continually increases.  
C. Continually decreases  
D. Increases for a while and decreases thereafter.  
E. Is constant for a while and decreases thereafter.

9. A ball is fired by a cannon from a cliff as shown in the figure. Which of the paths would the cannon ball most likely follow?

A. A  
B. B  
C. C  
D. D  
E. E
10. A boy throws a steel ball straight up. Consider the motion of the ball only after it has left the boy's hand but before it touches the ground, and assume the forces exerted by the air are negligible. For these conditions, the force(s) acting on the ball is (are):
   A. A downward force of gravity along with a steadily decreasing upward force.
   B. A steadily decreasing upward force from the moment it leaves the boy's hand until it reaches its highest point; on the way down there is a steadily increasing downward force of gravity as the object gets closer to the earth.
   C. An almost constant downward force of gravity along with an upward force that steadily decreases until the ball reaches its highest point; on the way down there is only a constant downward force of gravity.
   D. An almost constant downward force of gravity only.
   E. None of the above. The ball falls back to ground because of its natural tendency to rest on the surface of the earth.

11. A bowling ball accidentally falls out of the cargo bay of an airliner as it flies along in a horizontal direction. As observed by a person standing on the ground and viewing the plane as in the figure, which path would the bowling ball most closely follow after leaving the airplane?
   A. A
   B. B
   C. C
   D. D
   E. E

12. A large truck breaks down on the road and receives a push back to town by a small compact car as shown in the figure. While the car, still pushing the truck, is speeding up to cruising speed:
   A. The amount of force with which the car pushes on the truck is equal to that with which the truck pushes back on the car.
   B. The amount of force with which the car pushes on the truck is smaller than that with which the truck pushes back on the car.
   C. The amount of force with which the car pushes on the truck is greater than that with which the truck pushes back on the car.
   D. The car's engine is running so the car pushes against the truck, but the truck's engine is not running so the truck cannot push back against the car. The truck is pushed forward simply because it is in the way of the car.
   E. Neither the car nor the truck exerts any force on the other. The truck is pushed forward simply because it is in the way of the car.

13. An elevator is being lifted up an elevator shaft at a constant speed by a steel cable as shown in the figure. All frictional effects are negligible. In this situation, forces on the elevator are such that:
   A. The upward force by the cable is greater than the downward force of gravity.
   B. The upward force by the cable is equal to the downward force of gravity.
   C. The upward force by the cable is smaller than the downward force of gravity.
   D. The upward force of the cable is greater than the sum of the downward force of gravity and a downward force due to the air.
   E. None of the above. (The elevator goes up because the cable is being shortened, not because an upward force is being exerted on the elevator by the cable.)
14. The positions of two blocks at successive 0.20-second time intervals are represented by the numbered squares in the figure. The blocks are moving toward the right. Do the blocks have the same speed?
   A. No.
   B. Yes, at instant 2.
   C. Yes, at instant 5.
   D. Yes, at instants 2 and 5.
   E. Yes, at some time during the interval 3 to 4.

15. The positions of two blocks at successive 0.20-second time intervals are represented by the numbered squares in the figure. The blocks are moving toward the right. The accelerations of the blocks are related as follows:
   A. The acceleration of “a” is greater than the acceleration of “b”.
   B. The acceleration of “a” equals the acceleration of “b”. Both accelerations are greater than zero.
   C. The acceleration of “b” is greater than the acceleration of “a”.
   D. The acceleration of “a” equals the acceleration of “b”. Both accelerations are zero.
   E. Not enough information is given to answer the question.

16. A woman exerts a constant horizontal force on a large box. As a result, the box moves across a horizontal floor with a constant speed \( v_0 \). The constant horizontal force applied by the woman:
   A. Has the same magnitude as the weight of the box.
   B. Is greater than the weight of the box.
   C. Has the same magnitude as the total force which resists the motion of the box.
   D. Is greater than the total force which resists the motion of the box.
   E. Is greater than either the weight of the box or the total force which resists its motion.

17. A woman exerts a constant horizontal force on a large box. As a result, the box moves across a horizontal floor with a constant speed \( v_0 \). If the woman doubles the constant horizontal force that she exerts on the box, the box then moves:
   A. With a constant speed that is double the speed \( v_0 \).
   B. With a constant speed that is greater the speed \( v_0 \), but not necessarily double.
   C. For a while with a speed that is constant and greater than \( v_0 \), then with a speed that increases thereafter.
   D. For a while with an increasing speed, then with a constant speed thereafter.
   E. With a continuously increasing speed.

18. A woman exerts a constant horizontal force on a large box. As a result, the box moves across a horizontal floor with a constant speed \( v_0 \). If the woman suddenly stops applying a horizontal force to the box, then the box will:
   A. Immediately come to a stop.
   B. Continue moving at a constant speed for a while and then slow to a stop.
   C. Immediately start slowing to a stop.
   D. Continue at a constant speed.
   E. Increase its speed for a while and then start slowing to a stop.
19. In the figure, student “a” has a mass of 95 kg and student “b” has a mass of 77 kg. They sit in identical office chairs facing each other. Student “a” places his bare feet on the knees of student “b”, as shown. Student “a” then suddenly pushes outward with his feet causing both chairs to move. During the push while the students are still touching each other:
A. Neither student exerts a force on the other.
B. Student “a” exerts a force on student “b”, but “b” does not exert any force on “a”.
C. Each student exerts a force on the other, but “b” exerts a larger force.
D. Each student exerts a force on the other, but “a” exerts a larger force.
E. Each student exerts the same amount of force on the other.

20. An empty office chair is at rest on a floor. Consider the following forces: 1. A downward force of gravity. 2. An upward force exerted by the floor. 3. A net downward force exerted by the air. Which of the forces is (are) acting on the chair?
A. 1 only.
B. 1 and 2.
C. 2 and 3.
D. 1, 2, and 3.
E. None of these forces. (Since the chair is at rest there are no forces acting upon it.)
APPENDIX C

Informed Consent Document

Title of Study: Impact of available interactivity options on student learning and student satisfaction with instruction.

Investigators: Deanna L. Snyder Poudel, MS, MSM
                Joanne K. Olson, PhD

This is a research study. Please take your time in deciding if you would like to participate. Please feel free to ask questions at any time.

INTRODUCTION

The purpose of this study is to learn more about how the way students access their instructors and each other impacts how they learn and how they enjoy the class, both in the online and the on campus classroom. You are being invited to participate in this study because you are a student in one of the MCC courses being studied.

DESCRIPTION OF PROCEDURES

If you agree to participate in this study, your participation will last for five months during which time you will be asked to participate as usual in your coursework including the tests and surveys which will be used in this study. You may be asked to participate in a follow-up interview, according to your choice. During the study you may expect the following study procedures to be followed. You will complete, as part of your coursework, a twotests and two surveys which look at your understanding of some of the concepts being taught and how you like to learn. Towards the end of the class, you will be asked to complete a student experience form to gather information about your satisfaction with the class and the instructor. You may skip any question that you do not wish to answer or that makes you feel uncomfortable. During the last month of the semester a small number of the participants will be asked to be interviewed to gain a deeper understanding of how they communicated with the other students and the instructor of the course. Even if you are asked to participate in the interview, you may choose not to do so. All data
taken from the course will be confidential. No names will be associated with specific pieces of data, but will be assigned a random identifier so that the data analysis will be completely anonymous.

**RISKS**

While participating in this study you may experience the following risks: No risks are anticipated beyond the expected stress of being a student in the class.

**BENEFITS**

If you decide to participate in this study there may be no direct benefit to you. It is hoped that the information gained in this study will benefit society by helping instructors identify what ways they can improve their instruction, and design their courses to increase both student learning and student satisfaction with their coursework.

**ALTERNATIVES TO PARTICIPATION**

If you choose not to participate, though you will still be expected to complete the required components of the course for which you are enrolled, your data will not be included in the research.

**COSTS AND COMPENSATION**

You will not have any costs from participating in this study. You will not be compensated for participating in this study.

**PARTICIPANT RIGHTS**

Your participation in this study is completely voluntary and you may refuse to participate or leave the study at any time. If you decide to not participate in the study or leave the study early, it will not result in any penalty or loss of benefits to which you are otherwise entitled. If you do not complete the course, your data will not be used in the study.

**CONFIDENTIALITY**

Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy your records for quality assurance and data analysis. These records may contain private information.
To ensure confidentiality to the extent permitted by law, the following measures will be taken. Each student will be assigned a unique id code and section designator to be used to identify all data used in the study. The ids will be randomly generated to maintain anonymity. All records will be kept in electronic form in password protected files, or in hard copy in locked filing cabinets. Access to these data will be restricted to the investigators and the members of the IRB. At the end of the study, all records will be destroyed. If the results are published, your identity will remain confidential.

QUESTIONS OR PROBLEMS

You are encouraged to ask questions at any time during this study. For further information about the study contact Deanna L. Poudel at 816.672.2336 or Joanne Olson at 515.294.3315.

If you have any questions about the rights of research subjects or research-related injury, please contact the Human Subjects Research Office, 1138 Pearson Hall, (515) 294-4566; austimg@iastate.edu or the Research Compliance Officer, Office of Research Compliance, 1138 Pearson Hall, (515) 294-3115; dament@iastate.edu

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SUBJECT SIGNATURE

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document and that your questions have been satisfactorily answered. You will receive a copy of the signed and dated written informed consent prior to your participation in the study.

Subject's Name (printed) ____________________________________________

(Subject's Signature) ____________________________________________ (Date)

[If subject is under 18, a parent or guardian must give their consent.]

(Signature of Parent/Guardian or Legally Authorized Representative) (Date)

INVESTIGATOR STATEMENT

I certify that the participant has been given adequate time to read and learn about the study and all of their questions have been answered. It is my opinion that the participant understands the purpose, risks, benefits and the procedures that will be followed in this study and has voluntarily agreed to participate.

(Signature of Person Obtaining Informed Consent) (Date)


http://itech1.coe.uga.edu/itforum/paper63/paper63.htm


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