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ONLINE VERSUS FACE-TO-FACE BIOLOGY: A COMPARISON OF STUDENT
 TRANSACTIONAL DISTANCE, APPROACH TO LEARNING,
 AND KNOWLEDGE OUTCOMES

by

Mary Erin Riggins

Abstract of a Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

December 2014
ABSTRACT

ONLINE VERSUS FACE-TO-FACE BIOLOGY: A COMPARISON OF STUDENT TRANSACTIONAL DISTANCE, APPROACH TO LEARNING, AND KNOWLEDGE OUTCOMES

by Mary Erin Riggins

December 2014

Community colleges are among many other institutions increasing course offerings online, but there is still some concern about the quality of online learning. Educator concerns, a lack of empirical evidence on biology courses offered online, and the need for an equal opportunity for education support the need for clarification of the quality of distance education in biology, especially in the community college setting. Student attitudes, approaches to learning, and performance should all be studied in order to formulate a better evaluation of the quality and effectiveness of online courses (Svirko & Mellanby, 2008).

The purpose of this study was to determine whether there were differences in student perceptions of transactional distance, approaches to learning, and student learning outcomes in online versus face-to-face community college introductory biology courses. The results of this investigation indicate that some aspects of transactional distance did affect the participants’ desires for deep learning approaches. Also, except for perceptions of student interaction and collaboration, the online and face-to-face course experiences and outcomes seemed similar.
ONLINE VERSUS FACE-TO-FACE BIOLOGY: A COMPARISON OF STUDENT TRANSACTIONAL DISTANCE, APPROACH TO LEARNING, AND KNOWLEDGE OUTCOMES

by

Mary Erin Riggins

A Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

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Dean of the Graduate School

December 2014
DEDICATION

I dedicate this work to the most important educator in my life, my mom, Cathy Gilmore. There is no mother who ever showed her children more love, kindness, patience, dedication, and support as mine. Franklin D. Roosevelt once said, “When you get to the end of your rope, tie a knot and hang on.” Thanks, Mom, for being my knot, and for never letting me let go.

I am grateful to my family and friends for always cheering me on no matter what the venture. I thank my children, Savannah and Cooper, for allowing me time away from many dinners, soccer practices, school plays, and homework sessions in order to pursue this degree. I thank my husband, Christopher, for stepping up to muffle my absence during these times and for diving into this endeavor with me emotionally and financially, whether he wanted to or not. I thank my parents, Robbie and Cathy Gilmore, for imparting their worth of education and hard work and for their continued love, support, and many, many hours of the best babysitting a mom could ask for. I thank my sisters, Amy Walker and Caitlin Holley, for being the best friends a girl could have. My whole life I have felt that they were proud of me, and that has always been enough drive to keep me going. My friends, Dr. Kelly Rouse and Dr. Angela Bruni, were instrumental in my completion and perseverance during this process. Each of them held a candle for me, waving me through with words of guidance and encouragement. Finally, there is no way I could have done this without my partner in crime, Kathryn Morris. I thank her for the many unforgettable car rides to and from school and for the unforgettable friendship.
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CHAPTER I
INTRODUCTION

Based on current statistics, growth in online coursework is expected to continue and presents a unique challenge to science educators (U.S. Department of Education, National Center for Education Statistics, 2011). Not only does course content need to be taught, but also the true nature of science and science process skills. Because science content and the nature of science are often enhanced through interactions within the lab and online classes are often offered for flexibility, another challenge in online learning is to provide these opportunities, interactivity and flexibility, in the proper amounts. Moore (1993) stated that closing the miscommunication gap and increasing the level of student engagement, often referred to as transactional distance within an online course, are reliant on interaction as well as learner autonomy and course structure. A student’s approach to learning (SAL), whether surface or deep, may also affect the ability to be successful in an online course (Biggs, 1987). In order to support the growth of online learning, courses need to be designed to include an appropriate balance between these elements in order for students to obtain deep knowledge of subject matter, grasp the true nature of science, and develop critical thinking skills.

Community College and Distance Education Demographics

Kadlubowski (2000) stated that today’s students are different from traditional students in higher education. Adults are entering or returning to higher education to keep up with societal or economic pressures. These adults are nontraditional students and face obstacles such as working full-time jobs and taking care of families. Due to these obstacles, they are unable to meet the time constraints and commitments of traditional higher education (face-to-face) classes (Kadlubowski, 2000). Distance education,
instruction between an instructor and student that are geographically separated, is an answer to this problem (Burgess, 2006). Due to the increased number of nontraditional students entering higher education, institutions are realizing the need for accommodating this population by increasing these distance education opportunities (Kadlubowski, 2000). Increases in technological abilities have allowed the instruction through distance education to be more similar to face-to-face classes (McIsaac & Gunawardena, 1996).

This increase in ability to distribute instructional content through online platforms will not only lead to a continued increase of nontraditional students to seek education in this manner, but also other life-long learners that are traditional undergraduate and graduate students, as well as high school students (Kadlubowski, 2000).

According to Allen and Seaman (2014), there were 7.1 million people enrolled in at least one online course in 2012. This represents 33.5% of higher education students. Although only 9.7% of 2800 colleges surveyed did not believe online education was important for their future plans, less than one-third of the academic leaders of the 2800 colleges believe that there will be no concerns about the quality of online learning in the next five years (Allen & Seaman, 2014). Disparagement about the quality of online learning is mostly due to the fact that online learners are thought to learn passively and may be isolated (Hara & Kling, 2000). Also, there has been a drastic increase in the concerns of academic leaders with online retention rates, 41% of academic leaders with concerns in 2013 versus 28% in 2009 and 27% in 2004. While retention rates in online courses are of concern, the reasons for the decreased retention rates seen especially by associate level institutions such as community colleges cannot be easily identified due to the population of nontraditional students enrolled. Whether students drop because of job-related or family responsibilities, or whether they drop because of the nature of the
student or course is unclear (Allen & Seaman, 2014). Although community colleges and other associate level institutions had a late start in the implementation of online learning, they are currently leading the trend in rising online course enrollments, accounting for at least 50% of the online learning population. This may be due to the idea that online courses may serve as a larger part of this type of institution’s mission as more nontraditional students are served. Of all disciplines studied, programs in health-related or other science fields had the fastest growth (Allen & Seaman, 2008).

Statement of the Problem

Although online course enrollments are so prevalent within community colleges and play an important role in carrying out this type of institution’s mission, baccalaureate institutions are still the most negative about the quality of online education (Allen & Seaman, 2012). While many of the students in community colleges will only obtain associates degrees, technical training, or continuing education credits, many will transfer to baccalaureate institutions. Transferability of courses taken online may become a problem if the quality of online instruction remains questionable.

Colleges are currently in a position where they need to offer positive learning experiences in order to lure students away from competing institutions. A positive learning experience within a course provides engagement, a student’s perceived value of a course, and a deeper learning approach (Floyd, Harrington, & Santiago, 2009). Engagement and the perceived value of a course may be directly related to the transactional distance, or miscommunication gap, that exists between a student and his or her learning environment. The possible relationship between a positive learning experience and transactional distance are summarized in Figure 1.
There is also evidence that the learning environment may influence students’ approaches to learning (Trigwell et al., 1999). Therefore, student attitudes, approaches to learning, and performance should all be studied in order to formulate a better evaluation of the quality and effectiveness of online courses (Svirko & Mellanby, 2008).

The purpose of this study was to identify student perceptions of transactional distance and approaches to learning in online versus face-to-face community college introductory biology courses. Transactional distance was studied based on the perceptions of instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy. Two categories of student approaches to learning have been studied: deep and surface. Deep approaches to learning include seeking understanding of new knowledge and making connections
between new knowledge and existing knowledge. Deep approaches are usually more intrinsically motivated than surface approaches, which are usually more extrinsically motivated. Surface approaches include rote memorization, little effort put forth by the student, and little involvement in making connections between new and existing knowledge (Biggs, 1987). The defining characteristics suggested by Biggs (1987) for each approach are summarized in Figure 2.

*Figure 2.* Characteristics of deep and surface approaches to learning as described by Biggs (1987).

This study also attempted to determine whether there was a difference in learning outcomes between the two different course formats, and whether a student’s choice of major had a relationship with the approach to learning for a gateway biology course.
Research Questions and Hypotheses

Based upon the literature and research problem stated, several questions were developed for the purposes of this study. The researcher intended to examine student perceptions toward two different factors concerning online learning and instruction: (a) transactional distance and (b) approach to learning, as well as learning outcomes based on the course format type. The study had one general research question divided into several sub-questions that more directly related to specific factors. The researcher hoped that these questions would facilitate the collection of data to illuminate reasons why one format may be more applicable than another.

Overarching Research Question: Do transactional distance, approach to learning, and learning outcomes differ between student populations of online biology courses versus those in face-to-face biology courses?

Specific Research Question One: How do students’ perceptions of transactional distance relate to their preferred approach to learning (deep versus surface)?

- Research Hypothesis One: It was hypothesized that there would be a significant relationship between the scores for instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy and the student’s score for deep approach to learning. It was also hypothesized that there would be a relationship between the scores for instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy and the student’s score for surface approach to learning. It was expected that this would be true for students online or in face-to-face classes.
Specific Research Question Two: Does the transactional distance perceived by students in online biology courses differ from the transactional distance perceived by students in face-to-face biology courses?

- Research Hypothesis Two: It was hypothesized that there would be a significant difference in the means of each of the following six categories of the Distance Education Learning Environment Survey (DELES) between the online and the face-to-face biology students: instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy.

Specific Research Question Three: Is there a difference between the original approach to learning (deep versus surface) taken by students in online versus face-to-face biology classes?

- Research Hypothesis Three: It was hypothesized that there would be a significant difference between the approach to learning (deep versus surface) taken by students in online biology courses versus those students in face-to-face biology courses.

Specific Research Question Four: Is there a difference in the original approach to learning (deep versus surface) and the approach to learning (deep versus surface) perceived at the end of the course as a function of transactional distance?

- Research Hypothesis Four: It was hypothesized that there would be a significant relationship between the DELES scores for the categories of instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy and the difference in deep approach scores for students at the beginning and end of the semester. It was also hypothesized
that there would be a significant relationship between the DELES scores for the categories of instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy and the difference in surface scores for students at the beginning and the end of the semester.

Specific Research Question Five: Do online biology students’ pretest and posttest scores differ from pretest and posttest scores of students in a face-to-face biology course?

- Research Hypothesis Five: It was hypothesized that a significant difference would be found in the differences of the means of unit posttest scores between the online biology students and the face-to-face biology students.

Specific Research Question Six: Do online biology students score as well as face-to-face biology students on an entrance exam to a subsequent science course for which biology is a prerequisite?

- Research Hypothesis Six: It was hypothesized that there would be a significant difference between the scores of the subsequent science course entrance exam of online biology and face-to-face biology students.

Specific Research Question Seven: Is there a difference between the approaches to learning (deep versus surface) for a student in a science or health related field when compared to the approaches to learning of students in other majors?

- Research Hypothesis Seven: It was hypothesized that there would be a significant difference in the approach to learning (deep versus surface) scores for students claiming a major other than those related to science or health-related fields
whether enrolled in online or face-to-face biology courses when compared to students that claim a science or health-related field.

Definition of Terms

The following terms are used in this study and should be understood in their complete context.

- **Active Learning**: This type of learning refers to learning that takes place actively, such as seeking of answers and knowledge, rather than passively accepting it from an instructor (Walker & Fraser, 2005).

- **Authentic Learning**: This type of learning includes real-life situations and includes everyday applications for knowledge (Walker & Fraser, 2005).

- **Deep Approach to Learning**: This type of learning usually refers to learning that takes place due to intrinsic motivation and is characterized by the desire to learn, understand, and the ability to apply knowledge on a deeper level (Biggs, 1987).

- **Dialogue**: Dialogue is described as a major part of the transactional distance theory and usually refers to the interaction that takes place between the instructor and learner (Moore, 1993).

- **Distance Education**: This type of education occurs when the teaching and the learning usually take place in different locations and usually at different times.

- **Face-to-Face Instruction**: This type of instruction occurs when the teaching and learning take place in the same location and at the same time.

- **Instructor – Centered Instruction**: This type of instruction is based on the traditional teachings of ancient Greeks where information is given by the instructor for the students to learn. Often times, this is a very structured learning
environment and is not designed to suit individual learners (Walker & Fraser, 2005).

- Instructor–Learner Interaction: This is the specific type of interaction that takes place between the instructor and the learner. This may include email, discussions, feedback, grades, etc. (Moore, 1989).

- Intrinsic Motivation: This type of motivation comes from inside a person and is not linked to external rewards.

- Learner Autonomy: This refers to the responsibility that a learner takes for his or her own learning (Moore, 1993). While a person may have a strong level of autonomy, he or she may not have a strong ability to apply knowledge to new situations. Learner autonomy is used synonymously with student autonomy.

- Learner–Content Interaction: This is the specific type of interaction that takes place between the learner and the content of a course. This may include but is not limited to the amount of resources accessed by the student and the time spent studying those resources in order to learn the content matter (Moore, 1989).

- Learner–Learner Interaction: This is the specific type of interaction that takes place between the learners, or peers, in a course. This may include emails, discussions, group assignments, etc. (Moore, 1989).

- Nontraditional Student: This refers to adult learners who are usually of the nontraditional college age, often have other responsibilities such as work and caring for families, and may not have a traditional high school diploma (“Nontraditional undergraduates,” n.d.).

- Structure: This refers to the rigidity of a course and the amount the course may vary in order to meet the needs of individual students (Kang & Gyorke, 2008).
• Student Approach to Learning: This is the approach to learning taken on by the student and includes both deep and surface. A student’s approach may be different in different courses and situations and may also change (Biggs, 1987).

• Student–Centered Instruction: This type of instruction revolves around the individual learner and is usually much less structured than instructor–centered instruction.

• Surface Approach to Learning: This type of learning usually refers to a survival technique for learning and involves more memorization (Biggs, 1987).

• Traditional Student: This student is of the normal age range for college, usually post-secondary education, and does not have major responsibilities such as work and family responsibilities compounding school responsibilities (“Nontraditional undergraduates,” n.d.).

• Transactional Distance: This is the pedagogical distance felt by students within a course, and not the geographical distance. This pedagogical distance may lead to miscommunication and misunderstandings (Chen, 2001).

Delimitations

The results of this study are delimited to the particular students who were enrolled in three online General Biology I with Lab courses and three face-to-face General Biology I with Lab courses at a southern community college during the summer 2014 semester; therefore, this study may not be generalized beyond this student population type. These students were of varying majors and not distributed equally by gender, age, nor ethnicity. All students were required to complete the questionnaires and pretests and posttests for homework or classwork assignments and were expected to answer questions as carefully and thoughtfully as possible; however, only completion credit was given, and
that may have led to thoughtless answering by some students. Participants for the study were only those that returned a signed consent form and were of at least 18 years of age.

**Limitations and Discussion**

While course content was the same in each of the courses, online and on-site, the courses were offered within different timeframes. The online courses and two of the face-to-face courses were offered for ten weeks, while one of the face-to-face courses was a compressed course and only lasted for four weeks. The students were selected from courses offered during the summer semester, and the summer semester student population usually varies from fall and spring semester student populations due to several factors. For example, there may have been an increased population of traditional students due to students who returned home from four-year institutions for summer but continued to take courses through the break. Instructors for the courses, therefore teaching styles, were not constant as the participants were selected from onsite and online biology courses from different campuses of the institution. Also, the researcher served as researcher and instructor for two of the courses: one online and one on-site. Finally, all pretests were given at the beginning of the semester while each posttest was given at the end of each unit. The ability to mark exactly when knowledge was gained, during the specific unit or before, was not measurable by this study, nor was it the goal of this study.

**Assumptions**

All questionnaires, pretests, and posttests were part of the course requirements; therefore, the researcher assumed that students would answer all questions to the best of their abilities and that all students would complete all study components. Also assumed was that the instruments being used were able to measure content learned. Finally, it was assumed that students were taking the pretest, posttest, and questionnaires themselves
because these were not proctored. There was a possibility that students answered
questions thoughtlessly or allowed someone else to answer questionnaires for them
because they were distributed online and were anonymous.

Justification

Imparting scientific literacy is a challenge often imposed upon tertiary biology
instructors due to the decline in students taking physical sciences and the lack of certified
secondary instructors. This has led to a much larger population of students from varying
majors, including science, who must learn scientific literacy from tertiary biology
instructors, and many science educators and scientists will take at least one science
course online throughout their education. Therefore, the clarification of the quality of
distance education in biology is necessary (Quinn, 2011). Empirical evidence on the
relationships among approach to learning, transactional distance, and learning outcomes
in distance education in biology is lacking, but what has been shown, in limited studies of
biology, chemistry, and physics, is that increasing relevance, engagement, and perceived
course value encourages deeper learning approaches; deeper learning approaches may
increase learning outcomes (Svirko & Mellanby, 2008). Many of these studies, however,
do not compare completely online and completely face-to-face courses at the same
institution. Also, after a thorough search through the available literature, the focus of
online learning investigations seems to be mostly focused on graduate students or those
of non-science related fields.

The goal of education is to promote a deeper learning approach in which students
seek knowledge and make connections because a student’s approach to learning may be
directly related to learning outcomes, course satisfaction, and retention. Although
students often have a preferred approach to learning, the type of instruction or learning
context may lead a student to adopt an approach that is more fitting to the learning environment (Garrison & Cleveland-Innes, 2005; Yonker, 2011). Thus, further investigation into other underlying reasons for the use of a specific strategy, deep or surface, as well as when or if the strategy changes, is warranted (Yonker, 2011). Students’ approaches to learning could also influence their perceptions of a course, which may influence transactional distance, learning outcomes, and retention rates in online courses. Success in these courses, then, may perhaps rely on the ability of an instructor to personalize instruction for individual students; however, the pedagogical practices of science teaching are heavily rooted in didactic, teacher-centered practices (Quinn, 2011). Garrison and Cleveland-Innes (2005) stated that contextual factors that may lead to individualized learning, therefore deeper learning, include workload, time constraints, various types of evaluations, opportunities for metacognition, more responsibility for course management placed on the student, and empathy, enthusiasm, and support from the instructor. Although there have been suggestions about how to individualize online courses, this is still a daunting task and one that should be researched (Huang, 2002); however, this task is beyond the scope of this study. Learning more about the individual student learning approaches and perceptions and satisfaction within a course may help to provide answers on how to best design an online course for each individual learner. Because current trends in distance education pose evidence for an increase in availability of science course offerings in the future, courses need to be designed to include the appropriate amount of subject content, interaction, and distance in order for students to grasp the true nature of science and develop critical thinking skills. The findings of this study may lead to the understanding of student perceptions of certain aspects of online courses leading to the ability of a more personalized and effective course design. Also,
information obtained from this study may aid counselors and students in choosing
courses by providing more insight about the type of student who is likely to be successful
within this type of course.

Summary

This chapter has stated the problem and research questions studied, as well as
listed the limitations, assumptions, and the justification for the study’s purpose. The
following chapter will explain the theoretical foundation behind the study as well as
include a description for the theories included in the conceptual framework. It will also
contain descriptions of the specific factors that will be investigated within this study and
examples of findings from previous studies.
CHAPTER II
REVIEW OF RELATED LITERATURE

Introduction

Many postsecondary institutions have increased the number of courses that they offer in an online environment. The U.S. Department of Education, National Center for Education Statistics (2011) stated that in the 2007/08 academic year, 20% of all undergraduates and 22% of all post baccalaureates took at least one class online. During the same year, 4% of undergraduates completed their entire programs online while 9% of post baccalaureates completed entire programs online (U.S. Department of Education, 2011). Northrup (2002) found through a study of graduate students in an online course that the main reasons students took courses online were convenience and flexibility, as 77% of the participants lived close enough to take the class on campus. This growth in online coursework is expected to continue and presents a unique challenge to science educators. Not only does the course content need to be taught, but also the true nature of science and science process skills need to be conveyed. These skills are most often taught through laboratory activities within the traditional face-to-face instructional format; however, time and space are often constrained within this type of environment (Mawn, Carrico, Charuk, Stote, & Lawrence, 2011). Online courses designed to offer flexibility, as well as the nature of science activities through inquiry, may offer a solution to this problem. Mawn et al. (2011) provided evidence that hands-on and field-based experiments could be incorporated within an online course, but suggested that by offering more open-ended experiments, allowing for the formation of a scientific community (peer–peer communication), and giving attention to process-related objectives, the
activities would be more effective at building knowledge of the nature of science and science process skills, therefore promoting deeper learning.

Because the nature of science is often enhanced through interactions and communication within the classroom, another challenge in online learning is to provide these factors in the proper amounts. Although U.S. colleges are increasing the courses and degree programs offered online due to their popularity, many students and teachers feel a lack of interaction negatively affects the course experience (McBrien, Jones, & Cheng, 2009). Northrup (2001) found that, while studying graduates in an online environment, most students were frustrated by too much interaction within a course, but believed that some interaction with the instructor, peers, content, and learning activities was important for learning. Murray, Perez, Geist, and Hedrick (2012) examined 100 students who had completed an online digital literacy course in a U.S. regional university and found that ungraded materials were perceived by the students to be ancillary from the course support and primary lecture materials and were often ignored due to time constraints felt by the students. Thus, online courses designed to include materials that all seem relevant and necessary for a grade may improve student–content interaction, thereby improving student success and learning. Because student success and learning are important for the quality of online education, it is important to learn more about the aspects of the learning environment in order to build upon its quality. Therefore, this chapter discusses the theoretical foundation and conceptual framework upon which this study is built. The major areas of study included are those of transactional distance and student approach to learning.
Theoretical Foundation:

Moore’s Transactional Distance Theory

Moore (1980) proposed a theory of transactional distance to describe how the interaction and structure of learning activities could affect the student’s ability to feel close or distant to an online class. This transactional distance may be felt in any educational environment, but has special implications in the circumstance of distance learning (Moore, 1991). His theory has been revised several times and used by many researchers to define what aspects affect the “distance” a learner feels from a course. Distance, in this instance, is described by the amount of student engagement within a course, and not the actual physical distance between the learner and the instructor (Moore, 1993). Dialogue, structure, learner autonomy, technical difficulties, convenience, pedagogy, student ability to use the internet, and previous student experience with online courses are some of the recurrent themes explored in previous studies (Chen, 2001; McBrien et al., 2009). Moore’s (1993) theory of transactional distance focuses upon course structure and dialogue and was later amended to include learner autonomy (Moore & Kearsley, 2005), but there is still a need for empirical research describing the many other factors that contribute to transactional distance. In order for research to extend upon this theory, more must be known about the interactions that take place during a course, as well as the student perceptions about the course. Walker and Fraser (2005) designed the Distance Education Learning Environments Survey in order to detect the student perceptions on certain aspects in online classes. These aspects are (a) instructor support, (b) student interaction and collaboration, (c) personal relevance, (d) authentic learning, (e) active learning, (f) student autonomy, and (g) enjoyment. These specific aspects were chosen in order to measure the psychosocial
characteristics of students in online classes and get an overall idea of student satisfaction with online classes. Student satisfaction is linked to the social interactions within the class (Swan, 2001), and social interactions lead to a feeling of presence within the online classes that ultimately leads to more student success (Palloff & Pratt, 1999). The enjoyment scale questions were designed solely for the online students and were left out of this study due to the comparison between online and face-to-face students.

Biggs’ Student Approach to Learning Theory

The approach to learning that a student takes may also affect the ability to be successful in a distance education course. Biggs’ (1987) approach to learning theory, SAL, describes three different student approaches: surface, achieving, and deep. Student Approaches to Learning theory states that a student’s perceptions and the learning activities are both important to learning. Therefore, decreasing the transactional distance a student feels from a course with a strategic design of course structure and interaction may play a large role in a student’s perceptions of the course and the approach to learning a student takes. In studies by McBrien et al. (2009) and Armstrong (2011), students of different ages and ethnicities in a variety of courses felt that more student–faculty communication was necessary for a positive online learning experience. These students perceived that a lack in communication allowed for only surface or strategic learning to take place online, whereas deep learning could be obtained in face-to-face courses. Lee and Rha (2009) found that a highly structured course could serve as a substitute to an instructor; however, cognitive achievement was much lower in this environment than in the interactive course. Student interaction and collaboration, as well as student satisfaction, are all important for the development of a successful distance learning environment (Walker & Fraser, 2005). As a better balance among these elements is
approached, the distance can be minimalized, and more effective student learning on a
much deeper level may take place.

Thus far, distance education pedagogy has been primarily based on answering the
question of how spatial distance can be bridged between instructor and student (Lee &
Rha, 2009). Another primary focus of distance education has been on the structure and
technology; however, studies of student learning approaches determined by their
perceptions of the course are also necessary for efficient course development (McBrien et
al., 2009). More research on the factors that affect the transactional distance a student
feels leading to better course design may help to eliminate spatial distance as an issue.

Conceptual Framework

Drawing on ideas from M. G. Moore’s transactional distance theory (Moore, 1993) and Biggs’ approach to learning theory (Biggs, 1987), this study was designed in
order to identify student perceptions of transactional distance in the categories of
instructor support, student interaction and collaboration, personal relevance, authentic
learning, active learning, student autonomy, and student enjoyment, as well as student
perceptions of approach to learning and the relationship between these and learning
outcomes. Therefore, the conceptual framework of this study included aspects of both
the transactional distance theory and approach to learning theory.

Transaction was first explained by Dewey (Dewey & Bentley, 1949) as the
interplay among the environment, instructor, learners, and behavioral patterns in a
learning setting. Distance education was referred to as the education that occurs between
teacher and learners who were separated and must contain a set of special teaching and
for studying student perceptions of transactional distance known as the transactional
distance theory. This theory stated that the closeness a student feels to a course was reliant upon the course dialogue and structure. In his theory, dialogue specifically referred to teacher-learner interaction, even though he stated that there were three forms of transactional interaction: teacher-learner, learner-learner, and learner-content. This study focused on the three forms of transactional interaction instead of only teacher-learner dialogue. Structure referred to the ability a course had to provide varied instruction for different learner types due to the amount of flexibility that existed within the course objectives, teaching strategies, and methods of evaluation (Moore, 1991).

Many studies have used this theory as the conceptual framework; however, they included variations such as the inclusion of factors other than structure and dialogue that promote transactional distance. Chen (2001) extended on this theory in order to better address the issues that affected learning in distance education. Instead of only analyzing the amount of course structure and dialogue as key factors in student perception of distance, she included the student’s skill with use of the internet and the amount of previous distance education experienced (Chen, 2001). Walker and Fraser (2005) proposed that the psychosocial dynamic of online courses was much different from traditional face-to-face classes and developed an instrument to determine transactional distance by measuring student perceptions of (a) instructor support, (b) student interaction and collaboration, (c) personal relevance, (d) authentic learning, (e) active learning, and (f) student autonomy. This instrument also measured enjoyment which was believed to be significant in determining transactional distance. This variation of Moore’s transactional distance theory was of interest to this researcher as it addressed the issues of distance education in a much more multi-faceted approach and was included in the conceptual framework for
this study. Figure 3 represents the concepts that Walker and Fraser (2005) suggest as factors to effective online learning.

![Diagram of Walker's and Fraser's (2005) model for determining transactional distance.](image)

Figure 3. Walker’s and Fraser’s (2005) model for determining transactional distance.

**Instructor Support**

Instructor support, or instructor – learner interaction, is thought to be the most important aspect for distance education (Holmberg, 1986; Saba, 2003) and is believed to be paramount for learning to take place by reinforcing comprehension (Moore, 1989; Moore & Kearsley, 1996). Several studies have found that instructor support is the single-most significant factor in students’ perceived learning and course satisfaction (Frederickson, Pickett, Shea, Pelz, & Swan, 2000). While this type of interaction is important for both online and face-to-face classes, interaction is even more important for online courses because students often wait for feedback from an instructor before moving on in the course (Northrup & Rasmussen, 2000). This helps to explain the importance of timely feedback. As instructor–learner interaction is enhanced, transactional distance is
decreased (Brown & Voltz, 2005; Collison, Elbaum, Haavind & Tinker, 2000; Moore & Kearsley, 1996; Saba & Shearer, 1994). This decrease in transactional distance is partly due to the advancements of communication technology and allows for instruction to be more student-centered and designed accordingly to each student’s level of learner autonomy (Kearsley, 2000; Moore & Kearsley, 1996). If instructor support is decreased, then transactional distance is believed to increase, as well as the structure of the course. This increase in transactional distance is partly due to the increase in structure of the course and decrease in individualization of instruction that will occur when instructor–learner interaction is limited (Moore, 1989). Not only does a decrease in the instructor support cause an increase in transactional distance, but also a decrease in the retention for a course and the perceived satisfaction (Berge, 1999). These effects are summarized in Figure 4.

![Figure 4](image)

*Figure 4.* The relationship among instructor support, retention, satisfaction and transactional distance as described in previous research (Berge, 1999).

**Student Interaction and Collaboration**

The amount of interaction within a course is believed to be an indicator of student outcomes (Burgess, 2006) as well as retention rates and instructor effectiveness (Flottemesch, 2000). Moore (1989) also believes that learner-learner interaction is essential for successful online courses. The interactions that take place among learners within a course are also thought to be able to increase satisfaction with the course, and thereby increase retention. This may be due to students’ abilities to share meaning of
content with each other in order to better understand and apply it (Berge, 1999). Learner–learner interaction may allow for more collaborative study and decreased feelings of isolation (Northrup, 2001). This may also provoke students to have more contact with course materials leading to better learning outcomes, increased satisfaction, decreased transactional distance, and increased retention (Liaw & Huang, 2000). These findings are summarized in Figure 5.

![Figure 5](image.png)

*Figure 5.* The relationship among learner-learner interaction, retention, satisfaction, and transactional distance (Liaw & Huang, 2000).

**Personal Relevance, Authentic Learning, and Active Learning**

Transactional distance can also be associated with the types of learner–content interactions that take place within a course. Transactional distance can be affected by this type of interaction not only in distance education courses, but also in face-to-face courses. This is certainly believed to be the case when meaningful dialogue and learning are not taking place (Moore, 1993). Content must be perceived by the students to be meaningful and relevant (Driscoll, 2000) by incorporating authentic learning activities and real-life applications (Hannafin & Land, 1997; Herrington & Oliver, 1995). Personal relevance may also be used to initially engage students and increase their perceptions to course value leading to increased engagement and deeper approaches to learning (Floyd et al., 2009). Studies have shown that action learning may also influence a shift from a surface approach to learning to a deep approach to learning (Wilson & Fowler, 2005).
**Student Autonomy**

Student autonomy, also called learner autonomy, is the responsibility that a student takes for his or her own learning. Distance students are often found to have higher degrees of learner autonomy due to the fact that they must be more responsible for their own learning (Moore, 1973). Because learner autonomy increases with increasing transactional distance, Moore hypothesized that there is a relationship between transactional distance and learning style (Moore, 1991). The approach to learning theory (Biggs, 1987) states that there are three possible approaches to learning (learning styles): surface, strategic (achieving), and/or deep. Armstrong (2011) declared the basic characteristics of each, “Characteristics of deep learning include: looking for meaning, focusing on the central argument or concepts needed to solve a problem, interacting actively, distinguishing between argument and evidence, making connections between different modules, relating new and previous knowledge, and linking course content to real life” (Armstrong, 2011, p. 224). Surface learning represents learning of the basic content without ability for application, and strategic (achieving) learning represents an organized approach with more focus on what must be done for completing assignments and studying in order to compete for specific grades (Armstrong, 2011).

An examination of the literature revealed that studies comparing student perceptions of transactional distance (structure, dialogue, and autonomy), approaches to learning (deep and surface), and learning outcomes were lacking, especially in introductory biology. However, this examination of the literature did surface several studies that examine these factors in other subject areas, and especially with upperclassmen and graduates. Northrup (2002) studied graduate students in an online information technology course to determine their perceptions of interaction attributes
such as content interaction, conversation and collaboration, intrapersonal/metacognitive skills, and support. Interaction, overall, was found to be important to student satisfaction and motivation because students rated factors within each interaction attribute as important, but self-directedness (intrapersonal/metacognitive attribute) and timely feedback (support attribute) were deemed the most important by the students for online learning. Chen (2001) studied graduate students in online courses and found that students with an increased skill level with using the internet decreased the transactional distance. Also, the more discussions that a student took part in online decreased the transactional distance. According to the study by Garrison and Cleveland-Innes (2005), though, it is suggested that interaction does not necessarily translate to cognitive discourse, but it depends on structure through the design of the course and leadership through instructor support.

Lee and Rha (2009) examined levels of cognitive achievement and course satisfaction when comparing juniors in a highly structured, low interactive web-based instruction course with a low structured, highly interactive web-based instruction course. For learning characteristics such as memorizing, recalling of facts, and understanding, there were no significant differences between the groups. However, students in the interactive course scored much higher in critical thinking development than the students in the structured course. Another important finding during this investigation was that student-student interaction had been valued almost as highly as student-instructor interaction.

Hauser, Paul, and Bradley (2012) examined juniors in online and face-to-face management information systems classes and found that transactional distance and anxiety were positively correlated for both course formats. By reducing transactional
distance, anxiety was reduced, and performance was enhanced. Also, structure and autonomy were found to be significant for the online students while the emotive and interactive characteristics of transactional distance were significant for the face-to-face students.

Floyd et al. (2009) studied the effect of course value and cognitive engagement on the deep and surface learning strategies of 191 students in online and face-to-face business and technology courses of the freshman, sophomore, junior, and senior levels. They found that students who perceived engagement and course value were more likely to have deep learning approaches and less tendency toward using surface learning approaches. This study suggested that course value may play a larger role in promoting deeper learning strategies and that instructors should stimulate perceived course value by the use of examples from the real-world, students’ future careers, or students’ personal lives. Svirko and Mellanby (2008) studied second year pre-clinical medical students in a computer-aided neuroanatomy course and found that for those students who enjoyed the computer programs and found them to be user-friendly, there was an increase in deep learning approaches. The computer-aided courses also increased clinical relevance promoting course value and deep learning approaches.

A few studies of science courses offered online showed that using active learning through hands-on and field-based experiences within an online course increased enjoyment, science inquiry skills, and made the course more applicable, all possibly leading to increased deep learning approaches (Harlen & Doubler, 2004; Lin, Liang, & Tsa, 2012; Mawn et al., 2011, Mickle & Aune, 2008; Reeves & Kimbrough, 2004). Quinn (2011) compared students in online and face-to-face introductory biology courses through quantitative and qualitative analyses to determine the students’ learning
approaches and whether there was a difference between the approaches of the online and face-to-face students. She found that deeper learning approaches were adopted more often by the online students, while the face-to-face students adopted the surface learning approaches more often. A finding of even more interest was that 20% of the online students reported very little of either surface or deep approach, which may be associated with poor learning outcomes (Prosser & Trigwell, 1999). A study of the student perceptions and causes of transactional distance may help to explain the reasoning behind a disintegrated, or no approach to learning.

These studies addressed transactional distance in the categories of instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, student autonomy, and enjoyment, as well as the different approaches to learning. However, none of these studies employed these attributes all at once. Therefore, in order to add to previous research about the factors that affect transactional distance, student approach to learning, and learning outcomes, especially in science learning, it was important that this study take place.

Rationale for the Study

While much research has been conducted on the interactions that take place within distance education environments, learner autonomy has often been left out of the focus of research (Chen & Willits, 1998). Without the study of student perceptions of distance education courses including their feelings on autonomy, courses are destined to be more instructor–centered, therefore increasing transactional distance. Currently, technology allows for a possible shift from the traditional instructor–centered approach to instruction that is of a more student–centered approach. This more student–centered approach gives the students more control over how they learn and may possibly lead to
more intrinsic motivation, or deep approaches to learning (Dougherty, 1998). The success of students in distance education courses may very well rely on the ability of an instructor to personalize the learning for each individual student relevant to his or her specific perceptions of instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and enjoyment. These perceptions may rely on the student’s approach to learning or may even change his or her specific approach to learning, as well as affect the retention rates and learning outcomes for the courses.

More science course offerings will become available online in the future. Thus, such courses should be designed to include the appropriate amount of subject content, interaction, and “distance” in order for students to grasp the true nature of science and develop critical thinking skills. Therefore, the purpose of this study was to identify student perceptions of specific factors affecting transactional distance and student perceptions of approach to learning in community college distance education science courses as well as to determine how these perceptions were related to learning outcomes.

Summary

Because online courses are on the rise, it is imperative that online quality also be on the rise. Transactional distance and student approach to learning may affect the success rate of students that take online courses, so more must be known about the factors that affect these. Empirical evidence is lacking for the student perceptions of transactional distance factors, as well as for perceptions for approach to learning; therefore, this study incorporated both. The following chapter will discuss the participants, research design, methodology, and instruments used in order to collect data for this study.
CHAPTER III

METHODOLOGY

Introduction

The purpose of this study was to determine the effects of transactional distance, approach to learning, and learning outcomes when comparing online biology students to those in face-to-face biology courses. In this study, the overarching research question was, Do transactional distance, approach to learning, and learning outcomes differ between student populations of online biology courses versus those in face-to-face biology courses? This general question was divided into sub-questions with hypotheses statements to assist in the collection of data. This chapter presents the methodology and procedures of the study, along with information about the participants and data analyses.

Research Questions

The data was analyzed to address the following research questions and hypotheses:

Overarching Research Question: Do transactional distance, approach to learning, and learning outcomes differ between student populations of online biology courses versus those in face-to-face biology courses?

Specific Research Question One: How do students’ perceptions of transactional distance relate to their preferred approach to learning (deep versus surface)?

- Research Hypothesis One: It was hypothesized that there would be a significant relationship between the scores for instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy and the student’s score for deep approach to learning. It was also hypothesized that there would be a relationship between the scores for instructor
support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy and the student’s score for surface approach to learning. It was expected that this will be true for students online or in face-to-face classes.

Specific Research Question Two: Does the transactional distance perceived by students in online biology courses differ from the transactional distance perceived by students in face-to-face biology courses?

- Research Hypothesis Two: It was hypothesized that there would be a significant difference in the means of each of the following six categories of the Distance Education Learning Environment Survey (DELES) between the online and the face-to-face biology students: instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy.

Specific Research Question Three: Is there a difference between the original approach to learning (deep versus surface) taken by students in online versus face-to-face biology classes?

- Research Hypothesis Three: It was hypothesized that there would be a significant difference between the approach to learning (deep versus surface) taken by students in online biology courses versus those students in face-to-face biology courses.

Specific Research Question Four: Is there a difference in the original approach to learning (deep versus surface) and the approach to learning (deep versus surface) perceived at the end of the course as a function of transactional distance?
• Research Hypothesis Four: It was hypothesized that there would be a significant relationship between the DELES scores for the categories of instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy and the difference in deep approach scores for students at the beginning and end of the semester. It was also hypothesized that there would be a significant relationship between the DELES scores for the categories of instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy and the difference in surface scores for students at the beginning and the end of the semester.

Specific Research Question Five: Do online biology students’ pretest and posttest scores differ from pretest and posttest scores of students in a face-to-face biology course?

• Research Hypothesis Five: It was hypothesized that a significant difference would be found in the differences of the means of unit posttest scores between the online biology students and the face-to-face biology students.

Specific Research Question Six: Do online biology students score as well as face-to-face biology students on an entrance exam to a subsequent science course for which biology is a prerequisite?

• Research Hypothesis Six: It was hypothesized that there would be a significant difference between the scores of the subsequent science course entrance exam of online biology and face-to-face biology students.

Specific Research Question Seven: Is there a difference between the approaches to learning (deep versus surface) for a student in a science or health related field when compared to the approaches to learning of students in other majors?
• Research Hypothesis Seven: It was hypothesized that there would be a significant difference in the approach to learning (deep versus surface) scores for students claiming a major other than those related to science or health-related fields whether enrolled in online or face-to-face biology courses when compared to students that claim a science or health-related field.

Research Design

This study employed a quantitative quasi-experimental design to address the previously mentioned research questions. The participants, requirements of the study, and the design of each instrument were kept constant as not to sway results. Although the courses were taught by different instructors, the constancy of research design ensured the capture of the effect of type of course, online or face-to-face, on transactional distance, approach to learning, and learning outcomes.

At the beginning of the semester, and after receiving permission from the Institutional Review Board (IRB) and the community college of which the study was performed, students were recruited from three online biology courses and three face-to-face biology courses. The participants in the face-to-face classes were considered the control group while the students in the online classes were considered the experimental group because the effect of online learning on transactional distance, approach to learning, and learning outcomes was to be measured. The students were not randomly selected because they were chosen from six purposefully selected biology courses at a community college. Each student used his or her chosen confidential four-digit access code in lieu of putting his or her name on any of the questionnaires, pretests, posttests, or the entrance exam. This access code was documented on the consent form and collected
by a research associate to delineate between which materials were able to be used in the final analysis.

Students in all classes received the Revised Learning Process Questionnaire (R-LPQ-2F) at the beginning of the semester and again at the end of the semester, the Distance Education Learning Environment Survey (DELES) at the end of the semester, and a pretest and posttest for each of four units: (a) chemistry and biological molecules, (b) genetics, (c) the cell and cell membrane, and (d) cellular respiration and photosynthesis. Each pretest was given prior to the start of the unit, and the posttest was given at the end of each unit. Finally, all students took an entrance exam created by some of the science teachers of the higher level sciences at the community college. This entrance exam was given at the end of the course because the subsequent science classes actually started a few weeks after the final for this course. For all students, the DELES, the R-LPQ-2F, and pretests and posttests were given through Qualtrics. They were asked to print the completed survey screen which showed nothing but the proof of completion and turn in for credit as these were actual homework assignments for the course. The questionnaires through Qualtrics, however, only included the four digit access code as an identifier.

A number of statistical tests were used to answer the research questions. The dependent variables included approach to learning (deep or surface), perceived transactional distance, pretest and posttest scores, and entrance exam scores. The independent variable was the method of course delivery: online or face-to-face. This study did not have controls for gender, age, or ethnicity.
Participants

The participants for this study were a nonrandom, convenience sample because the participants were chosen from the researcher’s classes as well as classes taught by the researcher’s colleagues. The instructors for three online biology courses and three face-to-face biology courses at two different campuses of a southern community college were asked for permission to recruit participants from their courses for this study. Participation only included the agreement to allow the researcher to use data from the questionnaires, pretest, posttests, and the entrance exam and was strictly voluntary. This may have led to an uneven distribution of participants, or students agreeing to allow the researcher to analyze their data, for the courses. One online course and one face-to-face course were recruited from one of the campuses, while two online courses and two face-to-face courses were recruited from the other. The online instructors were given a news announcement and a long consent form fully explaining the study. Those were distributed to all students in order to recruit them as participants. They were also asked to email all students to help recruit participants. The instructors were asked to require all questionnaires, pretests, posttests, and the entrance exam as a part of the requirements for the course. All participants were over the age of 18, so no parental consent was required.

The participants in this study were divided into two subsets: online students and face-to-face students. The online students served as the experimental group because the effect that was to be measured was that of online learning on transactional distance, approach to learning, and learning outcomes. Therefore, the control group was made of the students in the face-to-face biology classes. A power analysis was done prior to the study in order to determine the appropriate number of students to recruit in order to prevent a Type II error.
Instruments

In order to determine the approach to learning of students to detect relationships among approach to learning and transactional distance \( (H_1) \), online versus face-to-face approaches to learning \( (H_3) \), changes in approach to learning \( (H_4) \), and individual student major \( (H_7) \), the Revised Two-Factor Learning Process Questionnaire (R-LPQ-2F) was used (see Appendix A). Permission to use the R-LPQ-2F for general research purposes and for the classroom is provided with the publication of the questionnaire (Kember, Biggs, & Leung, 2004). The R-LPQ-2F is a Likert scale that measures two main subscales: deep approach (DA) versus surface approach (SA). Numbers 1, 2, 5, 6, 9, 10, 13, 14, 17, 19, and 21 of the questionnaire represent deep learning motives. Numbers 3, 4, 7, 8, 11, 12, 15, 16, 18, 20, and 22 represent surface learning motives. Each question had the following answer choices: (a) this item is always or almost always true of me, (b) this item is frequently true of me, (c) this item is true of me about half the time, (d) this item is sometimes true of me, and (e) this item is never or only rarely true of me (Kember, Biggs, & Leung, 2004). The answer choices were rearranged to the following, though, in order to resemble the order of answer choices in another questionnaire taken at the same time: (a) this item is never or only rarely true of me, (b) this item is sometimes true of me, (c) this item is true of me about half the time, (d) this item is frequently true of me, and (e) this item is always or almost always true of me.

The comparative fit index (CFI) and the standardized root mean squared residual (SRMR) were used to detect unidimensionality for this instrument. The questionnaire’s ability to detect deep versus surface approach was tested and found to have a CFI of 0.804 and a SRMR of less than 0.049. Cronbach alpha coefficients were calculated for each subscale to show reliability. The alpha reliability score for DA is 0.82, and the
alpha reliability scores for SA is 0.71. Although the CFI did not meet the normal criteria of at least 0.95, SRMR and reliability were good and indicate that psychometric properties for this instrument were good (Kember et al., 2004). The 22 questions assessed in the R-LPQ-2F were:

1. I find that, at times, studying makes me feel really happy and satisfied.
2. I try to relate what I have learned in one subject to what I learn in other subjects.
3. I am discouraged by a poor mark on a test and worry about how I will do on the next test.
4. I see no point in learning material which is not likely to be in the examination.
5. I feel that nearly any topic can be highly interesting once I get into it.
6. I like constructing theories to fit odd things together.
7. Even when I have studied hard for a test, I worry that I may not be able to do well on it.
8. As long as I feel I am doing enough to pass, I devote as little time studying as I can. There are many more interesting things to do.
9. I work hard at my studies because I find the material interesting.
10. I try to relate new material, as I am reading it, to what I already know on that topic.
11. Whether I like it or not, I can see that doing well in school is a good way to get a well-paid job.
12. I generally restrict my study to what is specifically set as I think it is unnecessary to do anything extra.
13. I spend a lot of my free time finding out more about interesting topics which have been discussed in different classes.

14. When I read a textbook, I try to understand what the author means.

15. I intend to get my A Levels (or equivalent qualification) because I feel that I will then be able to get a better job.

16. I find it is not helpful to study topics in depth. You don’t really need to know much in order to get by in most topics.

17. I come to most classes with questions in mind that I want answering.

18. I learn some things by rote, going over and over them until I know them by heart even if I do not understand them.

19. I find I am continually going over my school work in my mind at times like when I am on the bus, walking, or lying in bed, and so on.

20. I find the best way to pass examinations is to try to remember answers to likely questions.

21. I like to do enough work on a topic so that I can form my own conclusions before I am satisfied.

22. I find I can get by in most assessments by memorizing key sections rather than trying to understand them.

In order to measure the deep approach score and surface approach score for each individual, the total for each of the deep preference question responses and the total for the surface preference questions were calculated. Answer choice and point values are represented by A = 1 point, B = 2 points, C = 3 points, D = 4 points, and E = 5 points. These values were inserted for each of the questions in the following equations: DA =
In order to determine the transactional distance perceived by each student and to help address hypotheses one, two, and four, the Distance Education Learning Environments Survey (DELES) was used (see Appendix B). Permission to use the DELES was obtained through email by Fraser (see Appendix C). The DELES is a Likert scale with measurements of one, two, three, four, or five for each item. These scores allowed for the location of any relationships between transactional distance and course delivery (online or face-to-face). The DELES was developed in order to be used in higher education courses, especially distance education, in order to measure the psychosocial component of learning and to lend to research about student enjoyment of online learning. The DELES contains 34 questions dispensed into six categories: (a) instructor support, (b) student interaction and collaboration, (c) personal relevance, (d) authentic learning, (e) active learning, and (f) student autonomy (Walker & Fraser, 2005).

Walker and Fraser (2005) investigated each of the items within the DELES for construct validity using factor analysis of a field test of 680 distance education students, which allowed for the determination that each item actually measured what it said to measure. The original instrument contained 48 items and was refined to 34 items after the factor analysis because any items that loaded less than 0.50 on their own scale or more than 0.50 on one of the other scales was omitted. Table 1 shows the specific items within each category and the factor analysis loading score.
Table 1

*Factor Loadings for DELES Items*

<table>
<thead>
<tr>
<th>DELES Item</th>
<th>Factor Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor Support</td>
<td></td>
</tr>
<tr>
<td>1. In this class, if I have an inquiry, the instructor finds time to respond.</td>
<td>0.69</td>
</tr>
<tr>
<td>2. In this class, the instructor helps me identify problem areas in my study.</td>
<td>0.73</td>
</tr>
<tr>
<td>3. In this class, the instructor responds promptly to my questions.</td>
<td>0.83</td>
</tr>
<tr>
<td>4. In this class, the instructor give me valuable feedback on my assignments.</td>
<td>0.84</td>
</tr>
<tr>
<td>5. In this class, the instructor adequately addresses my questions.</td>
<td>0.80</td>
</tr>
<tr>
<td>6. In this class, the instructor encourages my participation.</td>
<td>0.63</td>
</tr>
<tr>
<td>7. In this class, it is easy to contact the instructor.</td>
<td>0.62</td>
</tr>
<tr>
<td>8. In this class, the instructor provides me with positive and negative feedback on my work.</td>
<td>0.76</td>
</tr>
<tr>
<td>Student Interaction and Collaboration</td>
<td></td>
</tr>
<tr>
<td>9. In this class, I work with others.</td>
<td>0.90</td>
</tr>
<tr>
<td>10. In this class, I relate my work to others’ work.</td>
<td>0.83</td>
</tr>
<tr>
<td>11. In this class, I share information with other students.</td>
<td>0.85</td>
</tr>
<tr>
<td>12. In this class, I discuss my ideas with other students.</td>
<td>0.86</td>
</tr>
<tr>
<td>13. In this class, I collaborate with other students in the class.</td>
<td>0.90</td>
</tr>
<tr>
<td>14. In this class, group work is a part of my activities.</td>
<td>0.87</td>
</tr>
</tbody>
</table>
Table 1 (continued).

<table>
<thead>
<tr>
<th>DELES Item</th>
<th>Factor Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal Relevance</strong></td>
<td></td>
</tr>
<tr>
<td>15. In this class, I can relate to what I learn to my life outside of the college.</td>
<td>0.75</td>
</tr>
<tr>
<td>16. In this class, I am able to pursue topics that interest me.</td>
<td>0.69</td>
</tr>
<tr>
<td>17. In this class, I can connect my studies to my activities outside of class.</td>
<td>0.81</td>
</tr>
<tr>
<td>18. In this class, I apply my everyday experiences in class.</td>
<td>0.78</td>
</tr>
<tr>
<td>19. In this class, I link class work to my life outside of the college.</td>
<td>0.83</td>
</tr>
<tr>
<td>20. In this class, I learn things about the world outside of my college.</td>
<td>0.55</td>
</tr>
<tr>
<td>21. In this class, I apply my out-of-class experience.</td>
<td>0.70</td>
</tr>
<tr>
<td><strong>Authentic Learning</strong></td>
<td></td>
</tr>
<tr>
<td>22. In this class, I study real cases related to the class.</td>
<td>0.61</td>
</tr>
<tr>
<td>23. In this class, I use real facts in class activities.</td>
<td>0.77</td>
</tr>
<tr>
<td>24. In this class, I work on assignments that deal with real-world information.</td>
<td>0.80</td>
</tr>
<tr>
<td>25. In this class, I work with real examples.</td>
<td>0.84</td>
</tr>
<tr>
<td>26. In this class, I enter the real world of the topic of study.</td>
<td>0.69</td>
</tr>
<tr>
<td><strong>Active Learning</strong></td>
<td></td>
</tr>
<tr>
<td>27. In this class, I explore my own strategies for learning.</td>
<td>0.63</td>
</tr>
<tr>
<td>28. In this class, I seek my own answers.</td>
<td>0.79</td>
</tr>
<tr>
<td>29. In this class, I solve my own answers.</td>
<td>0.75</td>
</tr>
<tr>
<td><strong>Student Autonomy</strong></td>
<td></td>
</tr>
<tr>
<td>30. In this class, I make decisions about my learning.</td>
<td>0.65</td>
</tr>
</tbody>
</table>
Table 1 (continued).

<table>
<thead>
<tr>
<th>DELES Item</th>
<th>Factor Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>31. In this class, I work during times that I find convenient.</td>
<td>0.65</td>
</tr>
<tr>
<td>32. In this class, I am in control of my learning.</td>
<td>0.81</td>
</tr>
<tr>
<td>33. In this class, I play an important role in my learning.</td>
<td>0.75</td>
</tr>
<tr>
<td>34. In this class, I approach learning in my own way.</td>
<td>0.61</td>
</tr>
</tbody>
</table>

N = 680 (Walker & Fraser, 2005).

Walker and Fraser (2005) also determined the reliability for the DELES by determining Cronbach alpha coefficients for each category. The instructor support category has an alpha reliability of 0.87. The student interaction and collaboration category has an alpha reliability of 0.94. The personal relevance category has an alpha reliability of 0.92. The authentic learning category has an alpha reliability of 0.89. The active learning category has an alpha reliability of 0.89. The active learning category has an alpha reliability of 0.75. The student autonomy category has an alpha reliability of 0.79. A generally accepted “rule-of-thumb” states that this range of 0.75 – 0.94 is acceptable to excellent for reliability (George & Mallery, 2001). The answer choices for all 34 items are (a) Never, (b) Seldom, (c) Sometimes, (d) Often, and (e) Always. In order to measure the transactional distance for each category for each participant using the DELES, the means for each category were calculated.

Pretests and posttests were given in order to address hypothesis five. The pretests and posttests were given for each of four units: (a) chemistry and biological molecules, (b) genetics, (c) the cell and cell membrane, and (d) cell respiration and photosynthesis.
Each pretest was composed of 10 multiple choice questions with five answer choices per question. These questions were validated through face validity by a panel of experts on the dissertation committee as well as instructors at the community college where the study was performed. Each question was reviewed, and it was agreed that there was one possible correct answer choice offered and that the question measured content knowledge of the specific topic. The same questions were on the pretest and posttest for each unit in order to determine student knowledge gains for each unit (see Appendixes D, E, F, and G).

The entrance exam (see Appendix H) for subsequent science courses was given to address hypothesis six and was composed of 49 questions decided upon by the instructors of the higher level sciences at the community college where the study was performed. These questions were ones deemed to be basic biology knowledge needed prior to entry into their respective courses. In other words, they represented what the student should have learned in biology. These questions were also validated through face validity by an expert panel and instructors at the community college in the manner previously described.

Procedures

Upon approval of MGCCC (see Appendix I) and The University of Southern Mississippi’s IRB (see Appendix J), participants were recruited from three online biology courses and three face-to-face courses at a community college during the summer 2014 semester. In order to recruit participants, the researcher provided a letter of permission to recruit students from specific courses (see Appendix K) and a thorough explanation of the study through the long consent form (see Appendix L). Students who chose to participate could have dropped out of the study without penalty at any time.
In order to maintain confidentiality, students identified themselves on all pretests, posttests, the entrance exam, and questionnaires with their chosen four-digit access pin number. This pin number was known only to each individual student. The students were asked to write their pin numbers on the consent form, so a record could be kept of the students’ pin numbers in case a student forgot. The consent forms were signed and kept by a research associate in a locked file cabinet. Online students scanned the consent form and emailed it to the research associate. The consent forms from face-to-face courses were collected by a student research associate while the instructor was away from the room. The student research associate placed all signed and unsigned consent forms in an envelope and sent the sealed envelope to the research associate. All assignments were required for course credit, but responses remained anonymous. While all students were required to participate in the different activities for this study, they were not required to agree to be part of the study. So, findings were only analyzed using data from students agreeing to be part of the study. In order to maintain anonymity, the face-to-face students as well as online students took all questionnaires, pretests, posttests, and the entrance exam through Qualtrics (Qualtrics, Provo, UT). For credit, they took a screen shot of each submission screen and uploaded it into an assignment link. The submission screens only showed that the assignment was complete and did not show any answers to the questions. All results gathered through Qualtrics were password protected and only identified through the four-digit pin number for each student.

Although the contact hours for each course format, online or face-to-face, were the same, the online courses and two of the face-to-face courses extended through the length of the full summer semester while one of the face-to-face classes extended only through June. Due to this, the schedule for implementation of study materials was
different for each of the study groups. Table 2 shows the approximate research design for this study. Also, even though the lecture and lab objectives were the same for each course (Course of Study, Appendix M), different types of activities were incorporated into each. For example, recorded audio whiteboard lectures, virtual labs, and discussion boards (Appendixes N, O, and P) were included in the online class in the place of the face-to-face lecture with instructor, labs, and group activities and discussions. Figure 6 shows a comparison between the online and face-to-face learning environments.

![Figure 6. Comparison of online and face-to-face learning environment for courses within this study.](image)

After consent was received, the R-LPQ-2F and the Units 1-4 pretests were administered to the students. Consent was only for inclusion of an individual’s data into the final analysis and not for the actual participation in the activities. The activities were included in the normal course design. The R-LPQ-2F was given in order to determine the
students’ approaches to learning at the beginning of the semester, before any presentation of course material. The unit pretests were used to give an indication of prior knowledge, and along with the unit posttests, allowed for a detection of any knowledge gains after a unit was taught. Once the unit pretests were given, the material was taught for Unit 1, followed by a posttest on Unit 1. Posttests for Units 2–4 were given after each unit was taught.

The R-LPQ-2F was given again at the end of the semester in order to determine whether there was a change in the students’ approaches to learning. Also, at the end of the semester, the DELES was given to all students in order to determine the students’ perceptions of transactional distance in the biology course. This allowed the researcher to detect whether there was a difference in the transactional distance felt by online students when compared to face-to-face students.

Finally, an entrance exam to upper level science courses designed to assess the basic biological knowledge that should be learned in a biology course was given to the students as part of the final exam for the course. This allowed the researcher to determine whether there was a difference in the preparedness for higher science courses of online biology students and face-to-face biology students. The DELES, R-LPQ-2F, pretests, posttests, and the entrance exam allowed the researcher to determine whether a relationship existed among transactional distance, approach to learning, course format, and/or knowledge gains for this study.
Table 2

*Research Design for Experimental Group (Online) and Control Group (Face-to-face)*

<table>
<thead>
<tr>
<th>Week</th>
<th>Online and 10 week Face-to-face classes</th>
<th>4 week Face-to-face classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R-LPQ-2F, Pretest for Units 1-4</td>
<td>R-LPQ-2F, Pretest for Units 1-4</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Posttest Unit 1</td>
</tr>
<tr>
<td>3</td>
<td>Posttest Unit 1</td>
<td>Posttest Unit 2, Posttest Unit 3</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Posttest Unit 4, R-LPQ-2F, DELES, Entrance Exam</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Posttest Unit 2</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Posttest Unit 3</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>R-LPQ-2F, DELES</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Posttest Unit 4, Entrance Exam</td>
<td></td>
</tr>
</tbody>
</table>

Through the use of SPSS (Version 22.0), a number of statistical techniques were used in order to analyze data collected through these procedures. Pearson correlations
were used in order to address research questions one and four. A MANOVA was used in order to address research questions two, three, five, and seven. Finally, a t-test was used to address research question six.

Summary

The purpose of this study was to examine the perception of transactional distance, approach to learning, and learning outcomes of students in online biology courses when compared to those in face-to-face biology courses. This study examined the transactional distance perceived by the students through the use of the Distance Education Learning Environments Survey (DELES) and the approach to learning by the use of the Revised Two-Factor Learning Process Questionnaire (R-LPQ-2F). The student’s major was obtained through school records to determine whether there was a relationship between the student’s major and approach to learning. Pretests and posttests were used to determine the difference in learning outcomes between the online and face-to-face biology students as well as whether there were any units that seemed to require face-to-face instruction more so than others. Finally, an entrance exam designed by the instructors of the subsequent science courses of which biology is a prerequisite was used to determine whether the online students were as prepared as the face-to-face students to enter a science at the next level. The following chapter will include the findings from this study.
CHAPTER IV
ANALYSIS OF DATA

The purpose of this study was to determine the effects of transactional distance, approach to learning, and learning outcomes when comparing online biology students to those in face-to-face biology courses. Whether there was a relationship between approach to learning and transactional distance or a relationship between approach to learning and student academic major were also examined. Data was collected from students in three face-to-face General Biology I with Lab classes and three online General Biology I with Lab classes. The results of this study were used to determine whether a difference in transactional distance, approach to learning, and student learning outcomes existed based on the course format: online or face-to-face. The online classes were treated as the experimental group, while the face-to-face classes were treated as the control group.

Findings

Data for this study was collected from student answers on four unit pretests and posttests, the Distance Education Learning Environments Survey (DELES), the Revised Learning Process Questionnaire (R-LPQ-2F), and a comprehensive exam that served as an entrance exam for a subsequent science course. The unit pretests and posttests were used to determine student knowledge gains in specific units. The DELES was used to determine student scores for the transactional distance categories of (a) instructor support, (b) student interaction and collaboration, (c) personal relevance, (d) authentic learning, (e) active learning, and (f) student autonomy. The R-LPQ-2F was used in order to determine the students’ deep knowledge scores and their surface knowledge scores at the beginning of the semester and end of the semester. The entrance exam to a subsequent
science course was used to determine whether the online students and the face-to-face students were equally prepared in content knowledge to move onto the next level science course.

Data were quantitatively collected using SPSS (Version 22.0) to gather descriptives for participants in each of the instruments listed above, as well as several other statistical tests in order to answer all research questions. Descriptive data for gender, age, ethnicity, etc. was not collected and not presented in these findings. The instruments used to collect data for this study included the R-LPQ-2F (beginning and end of semester), the DELES, Units 1–4 pretests and posttests, and an entrance exam to a subsequent science course. Not all participants participated in every instrument. Table 3 shows the overall participation for this study in the control group (face-to-face), and Table 4 shows the overall participation for the experimental group (online).

Table 3

Total Participation for Control Group

<table>
<thead>
<tr>
<th>Instrument</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-LPQ-2F beginning of semester</td>
<td>50</td>
</tr>
<tr>
<td>R-LPQ-2F end of semester</td>
<td>46</td>
</tr>
<tr>
<td>DELES</td>
<td>48</td>
</tr>
<tr>
<td>Unit Pretests</td>
<td>43</td>
</tr>
<tr>
<td>Unit Posttests</td>
<td>43</td>
</tr>
<tr>
<td>Entrance Exam</td>
<td>43</td>
</tr>
</tbody>
</table>
Table 4

**Total Participation for Experimental Group**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-LPQ-2F beginning of semester</td>
<td>37</td>
</tr>
<tr>
<td>R-LPQ-2F end of semester</td>
<td>27</td>
</tr>
<tr>
<td>DELES</td>
<td>27</td>
</tr>
<tr>
<td>Unit Pretests</td>
<td>21</td>
</tr>
<tr>
<td>Unit Posttests</td>
<td>21</td>
</tr>
<tr>
<td>Entrance Exam</td>
<td>26</td>
</tr>
</tbody>
</table>

Tables 5 and 6 contain descriptive statistics for each of the groups’ pre and post deep and surface scores on the R-LPQ-2F and for each of the DELES categories.

Table 5

**Control Group R-LPQ-2F and DELES Descriptives**

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre deep approach</td>
<td>50</td>
<td>36.16</td>
<td>7.40</td>
</tr>
<tr>
<td>Pre surface approach</td>
<td>50</td>
<td>33.26</td>
<td>5.33</td>
</tr>
<tr>
<td>Post deep approach</td>
<td>46</td>
<td>37.93</td>
<td>8.94</td>
</tr>
<tr>
<td>Post surface approach</td>
<td>46</td>
<td>35.74</td>
<td>7.46</td>
</tr>
<tr>
<td>Instructor support</td>
<td>48</td>
<td>4.41</td>
<td>0.80</td>
</tr>
<tr>
<td>Student interaction</td>
<td>48</td>
<td>4.06</td>
<td>0.84</td>
</tr>
</tbody>
</table>
Table 5 (continued).

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal relevance</td>
<td>48</td>
<td>4.03</td>
<td>0.89</td>
</tr>
<tr>
<td>Authentic learning</td>
<td>48</td>
<td>4.00</td>
<td>0.89</td>
</tr>
<tr>
<td>Active learning</td>
<td>48</td>
<td>4.01</td>
<td>0.91</td>
</tr>
<tr>
<td>Student autonomy</td>
<td>48</td>
<td>4.36</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Note. Possible scores for pre deep approach, pre surface approach, post deep approach and post surface approach range from 11–55 with higher means signifying a higher tendency for that category. Possible scores for instructor support, student collaboration, personal relevance, authentic learning, active learning, and student autonomy range from 1–5 with higher means signifying a lesser feeling of transactional distance due to the category.

Table 6

*Experimental Group R-LPQ-2F and DELES Descriptives*

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre deep approach</td>
<td>37</td>
<td>38.46</td>
<td>5.69</td>
</tr>
<tr>
<td>Pre surface approach</td>
<td>37</td>
<td>32.70</td>
<td>6.08</td>
</tr>
<tr>
<td>Post deep approach</td>
<td>27</td>
<td>38.15</td>
<td>7.71</td>
</tr>
<tr>
<td>Post surface approach</td>
<td>27</td>
<td>33.04</td>
<td>6.92</td>
</tr>
<tr>
<td>Instructor support</td>
<td>27</td>
<td>4.11</td>
<td>0.93</td>
</tr>
<tr>
<td>Student interaction</td>
<td>27</td>
<td>3.04</td>
<td>1.17</td>
</tr>
<tr>
<td>Personal relevance</td>
<td>27</td>
<td>3.83</td>
<td>0.86</td>
</tr>
<tr>
<td>Authentic learning</td>
<td>27</td>
<td>3.79</td>
<td>0.87</td>
</tr>
</tbody>
</table>
Table 6 (continued).

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active learning</td>
<td>27</td>
<td>4.33</td>
<td>0.58</td>
</tr>
<tr>
<td>Student autonomy</td>
<td>27</td>
<td>4.59</td>
<td>0.44</td>
</tr>
</tbody>
</table>

Note. Possible scores for pre deep approach, pre surface approach, post deep approach and post surface approach range from 11–55 with higher means signifying a higher tendency for that category. Possible scores for instructor support, student collaboration, personal relevance, authentic learning, active learning, and student autonomy range from 1–5 with higher means signifying a lesser feeling of transactional distance due to the category.

The R-LPQ-2F is a questionnaire that assesses a student’s level of deep approach to learning as well as his or her surface approach to learning and is split into 11 questions that address a student’s deep approach and 11 that address a student’s surface approach. One point was given for each answer choice of A, two points for B, three points for C, 4 points for D, and 5 points for E. So, the possible scores for the deep surface approach ranged from 11 (if all answer choices were A, this item is never or rarely is true of me) to 55 (if all answer choices were E, this item is always or almost always true of me). The values were added for each of the questions listed in the instruments section of Chapter III in order to calculate the total deep approach, and the same was done for the surface approach questions. The higher the score for each approach (deep or surface) represented a higher tendency toward that specific approach. A similar scale was used to calculate the scores for each category of the DELES: A (never) = 1 point, B (seldom) = 2 points, C (sometimes) = 3 points, D (often) = 4 points, and E (always) = 5 points. The means were calculated for each category from a possible score range of 1 (all answers A, never) or 5 (all answers E, always). The higher the mean score for each category, the less that category was felt by participants to lead to feelings of transactional distance.
As seen in Table 5, the control group’s deep approach score increased from the beginning of the semester (M = 36.16) to the end of the semester (M = 37.93). The surface approach score also increased from the beginning of the semester (M = 33.26) to the end of the semester (35.74). Table 5 also shows that the scores for each of the DELES categories were very similar between the control and experimental groups, and that most of the means were on the higher end of the scale. Table 6 showed that the experimental group’s deep approach score decreased from the beginning of the semester (M = 38.46) to the end of the semester (M = 38.15), while the surface approach score increased from the beginning of the semester (M = 32.70) to the end of the semester (M = 33.04). For the experimental group, the DELES categories student interaction, personal relevance, and authentic learning all ranked lower than four, while instructor support, active learning, and student autonomy seemed not to be perceived as contributors to transactional distance.

Research Hypothesis One

Research hypothesis one stated that there would be a significant relationship between the DELES scores for instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy and the student’s score for a deep approach to learning. This hypothesis also stated that there would be a significant relationship between the DELES scores for instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy and the student’s score for a surface approach to learning. These relationships were thought to exist regardless of whether a student was in the control group or the experimental group. Table 7 contains the student data for deep approach and surface approach scores collected from the R-LPQ-2F given at the end of
the semester and the scores for each category of the DELES. This data includes all participants and is not separated by control and experimental groups.

Table 7

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

Pearson correlation values were found for each of the DELES categories and the deep approach score and for each of the categories and the surface approach score. For the deep approach, there were significant correlations found for the DELES categories of student interaction, personal relevance, authentic learning, and active learning; however, none of the DELES categories were significantly correlated with a student’s surface approach to learning. These findings indicate that, for participants in this study, their desires for a deep approach to learning the material was affected by their feelings about student interaction, personal relevance, authentic learning, and active learning. A student’s tendency towards a surface approach, though, was unaffected by the categories
of transactional distance. Because the hypothesis was that the deep and surface approach scores would be correlated to each of the categories of the DELES, the hypothesis has been accepted, but only for certain parameters. Most of the categories of the DELES did have an effect on the deep approach to learning score, but not on the surface score.

**Research Hypothesis Two**

Research hypothesis two stated that there would be a significant difference in the means of each of the six categories of the DELES (instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy) between the online and the face-to-face biology students. Table 8 contains the descriptive statistics collected from the DELES of the control group (face-to-face) and the experimental group (online).

Table 8

**Research Hypothesis Two Descriptive Statistics**

<table>
<thead>
<tr>
<th>DELES Category</th>
<th>Face-to-Face (n = 48)</th>
<th>Online (n = 27)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Deviation</td>
</tr>
<tr>
<td>Instructor support</td>
<td>4.41</td>
<td>0.80</td>
</tr>
<tr>
<td>Student interaction</td>
<td>4.06</td>
<td>0.84</td>
</tr>
<tr>
<td>Personal relevance</td>
<td>4.03</td>
<td>0.89</td>
</tr>
<tr>
<td>Authentic learning</td>
<td>4.00</td>
<td>0.89</td>
</tr>
<tr>
<td>Active learning</td>
<td>4.01</td>
<td>0.91</td>
</tr>
<tr>
<td>Student autonomy</td>
<td>4.36</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Note. The mean possible score range was 1–5 for each of the DELES categories, with the lower scores indicating more feelings that the category increases transactional distance.
Table 8 reveals that for the DELES categories of instructor support, student interaction, personal relevance, and authentic learning, the control group had higher means. Scores for active learning and student autonomy, however, ranked higher for the experimental group. In order to determine whether the groups differed significantly, a MANOVA was performed in SPSS (Version 22.0). The multivariate test revealed that the means for the DELES category scores of the control group were significantly different from the scores of the experimental group, Pillai’s Trace = 0.42, $F(6,68) = 8.35$, $p<0.001$, meaning that the transactional distance did differ between face-to-face and online student groups. Therefore, the hypothesis was accepted, but only for some of the suspected conditions. The tests of between-subjects effects revealed that only the subtest on student interaction was significantly different between the two groups, $F(1, 73) = 19.272$, $p<.001$.

Research Hypothesis Three

Research hypothesis three stated that there would be a significant difference between the approach to learning deep and surface scores of the online biology students versus the deep and surface scores of the face-to-face biology students. Table 9 displays the descriptives for the two groups’ approach scores.
Table 9

*Beginning of Semester Deep and Surface Scores of Control and Experimental Group*

<table>
<thead>
<tr>
<th></th>
<th>Face-to-Face (n = 50)</th>
<th>Online (n = 37)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deep approach</strong></td>
<td>Mean 36.16</td>
<td>Mean 38.46</td>
</tr>
<tr>
<td></td>
<td>Std. Deviation 7.40</td>
<td>Std. Deviation 5.69</td>
</tr>
<tr>
<td><strong>Surface approach</strong></td>
<td>Mean 33.26</td>
<td>Mean 32.70</td>
</tr>
<tr>
<td></td>
<td>Std. Deviation 5.33</td>
<td>Std. Deviation 6.08</td>
</tr>
</tbody>
</table>

Note. The mean possible score range was 11–55 for each approach with higher means indicating more of a tendency toward that approach.

Table 9 indicates that the deep approach score for the online group was initially higher than the deep approach score of the face-to-face group. This result also indicated that the surface approach score was higher in the face-to-face group than the surface score in the online group. However, SPSS (Version 22.0) was used to perform a MANOVA, and the multivariate test revealed that there was no statistical difference between the groups in the initial approach to learning for either deep or surface approach score, Pillai’s Trace = 0.03, $F(2, 84) = 1.44, p = 0.24$. These findings indicated that a student’s original approach to learning and the chosen course format did not affect each other. Therefore, the hypothesis has been rejected.

*Research Hypothesis Four*

Research hypothesis four stated that there would be a significant relationship between the DELES category scores and the change in the deep and surface approach scores from the beginning of the semester to the end of the semester for all students, whether online or face-to-face. The scores were calculated in the same manner as mentioned above for the R-LPQ-2F, but the difference was calculated between the two deep scores and the two surface scores. The discrepancy between the two deep scores
gives the change in deep approach, while the discrepancy between the two surface scores gives the change in surface approach. Table 10 displays the correlations for the difference in the deep approach scores and the difference in surface approach scores for each group when compared to the DELES category scores.

Table 10

**Correlations Between Difference in Deep and Surface Approach Scores and DELES Category Scores (N = 73)**

<table>
<thead>
<tr>
<th></th>
<th>Difference in Deep Approach</th>
<th>Difference in Surface Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pearson Correlation</td>
<td>Sig. (2-tailed)</td>
</tr>
<tr>
<td>Instructor support</td>
<td>0.08</td>
<td>0.53</td>
</tr>
<tr>
<td>Student interaction</td>
<td>0.14</td>
<td>0.24</td>
</tr>
<tr>
<td>Personal relevance</td>
<td>0.03</td>
<td>0.78</td>
</tr>
<tr>
<td>Authentic learning</td>
<td>0.12</td>
<td>0.30</td>
</tr>
<tr>
<td>Active learning</td>
<td>0.08</td>
<td>0.49</td>
</tr>
<tr>
<td>Student autonomy</td>
<td>0.02</td>
<td>0.88</td>
</tr>
</tbody>
</table>

As seen in Table 10, there was no significance found when comparing the difference in the approach to learning deep and surface scores at the beginning of the semester and at the end of the semester to the scores of the DELES categories. This indicated that transactional distance did not affect the approach to learning for these two groups of participants. Therefore, the hypothesis has been rejected.

*Research Hypothesis Five*
Research hypothesis five stated that there would be a significant difference in the differences of the means of unit posttest scores between the online and face-to-face biology students. There were four unit pretests and posttests given, each with 10 questions. Unit 1 included questions about chemistry and biological molecules. Unit 2 included questions about genetics. Unit 3 included questions about the cell and cell membranes. Unit 4 included questions about cell respiration and photosynthesis. Table 11 represents the descriptives for the pretest and posttest differences for each group in each unit. Table 12 represents the descriptives for the pretest and posttest differences for each group in each unit. Because each pretest and posttest included 10 questions, there was a total possible score range from zero (answering no questions correctly) to 10 (answering all questions correctly).

Table 11

Descriptives for Control Group Performance on the Unit Pretests and Posttests

| Unit | Pretest | | | Posttest | | |
|------|---------|---|---|---------|---|
|      | n       | Mean | Std. | n       | Mean | Std. |
| 1    | 50      | 4.52 | 1.74 | 48      | 5.34 | 2.20 |
| 2    | 50      | 4.30 | 1.76 | 47      | 6.44 | 2.62 |
| 3    | 50      | 4.04 | 2.32 | 48      | 6.81 | 2.26 |
| 4    | 50      | 3.40 | 1.85 | 47      | 5.62 | 2.46 |

Note. The mean possible score range for both the pretests and the posttests was 0–10, with 10 indicating a perfect score.
Table 12

*Descriptives for Experimental Group Performance on the Unit Pretests and Posttests*

<table>
<thead>
<tr>
<th>Unit</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean</td>
</tr>
<tr>
<td>1</td>
<td>36</td>
<td>4.17</td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>4.36</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>4.11</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>3.42</td>
</tr>
</tbody>
</table>

Note. The mean possible score range for both the pretests and the posttests was 0–10, with 10 indicating a perfect score.

Table 13 contains the descriptive statistics for differences in the performance on the posttests, alone, for each of the groups.

Table 13

*Control Group vs. Experimental Group Posttest Descriptive Statistics*

<table>
<thead>
<tr>
<th></th>
<th>Control (n = 43)</th>
<th>Experimental (n = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Deviation</td>
</tr>
<tr>
<td>Unit 1 Posttest</td>
<td>5.42</td>
<td>2.11</td>
</tr>
<tr>
<td>Unit 2 Posttest</td>
<td>6.47</td>
<td>2.59</td>
</tr>
<tr>
<td>Unit 3 Posttest</td>
<td>6.79</td>
<td>2.22</td>
</tr>
<tr>
<td>Unit 4 Posttest</td>
<td>5.60</td>
<td>2.36</td>
</tr>
</tbody>
</table>

Note. The mean possible score range for both the pretests and the posttests was 0–10, with 10 indicating a perfect score.
A MANCOVA performed in SPSS (Version 22.0) showed no significance in the performance of the two groups, Pillai’s Trace = 0.04, $F(3, 56) = 0.76, p = 0.52$. The value for the tests of between-subjects effects was $F(1, 58) = 1.71, p = 0.20$. These findings indicated that, for this particular study, the online and face-to-face students had similar knowledge outcomes for each of the four units. Therefore, the hypothesis had been rejected.

*Research Hypothesis Six*

Research hypothesis six stated that there would be a significant difference between the scores of the subsequent science course entrance exam of online biology and face-to-face biology students. The exam was created by several instructors of the courses that were taken subsequently to the General Biology I with Lab course. There were 49 total questions, so the possible score range was from zero (no answers correct) to 49 (all answers correct). Table 14 contains the descriptive statistics for the groups’ scores on this instrument.

Table 14

*Descriptive Statistics for Performance on the Entrance Exam to a Subsequent Science Course*

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group (Face-to-face)</td>
<td>43</td>
<td>28.65</td>
<td>1.30</td>
</tr>
<tr>
<td>Experimental Group (online)</td>
<td>26</td>
<td>30.04</td>
<td>2.01</td>
</tr>
</tbody>
</table>

Note. The mean possible score range was 0–49, with 49 indicating a perfect score.

Table 14 showed that the experimental group seemed to perform better than the control group on the entrance exam to a subsequent science course. However, the SPSS
(Version 22.0) was used in order to perform an independent $t$-test, and no significant difference was found between the groups’ scores, $t(67) = -0.61, p = 0.55$. This indicated that both of the groups, face-to-face and online biology students, were equally prepared for the next science course and that course format had no effect on the knowledge outcomes. Therefore, the hypothesis has been rejected.

*Research Hypothesis Seven*

Research hypothesis seven stated that there would be a significant difference between the deep and surface scores for students with science or health-related majors versus the deep and surface scores for students with majors other than ones that were science or health-related. Table 15 displays the descriptive statistics for the original approach to learning scores (deep and surface) for both the control and experimental groups when compared to student major. The deep approach was measured by adding the scores from the 11 questions on the R-LPQ-2F that measure deep approach. The answer choices were each given a value of 1, 2, 3, 4, or 5, so the possible score range was from 11 (if all answers were A, this item is never or only rarely true of me)–55 (if all answers were E, this item is always or almost always true of me). The surface approach score was calculated in the same manner by totaling the student scores for each of the questions that measured surface approach. Again, the possible score range was from 11 (if all answers were A, this item is never or only rarely true of me)–55 (if all answers were E, this item is always or almost always true of me). The higher the score for each approach (deep or surface) represented a higher tendency toward that specific approach.
Table 15

*Original Approach to Learning (Deep and Surface) Scores for Students When Compared to Academic Major*

<table>
<thead>
<tr>
<th>Group</th>
<th>Major</th>
<th>n</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep Approach</td>
<td>Control</td>
<td>15</td>
<td>37.40</td>
<td>8.22</td>
</tr>
<tr>
<td></td>
<td>Not science related</td>
<td>34</td>
<td>35.53</td>
<td>7.17</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>8</td>
<td>37.38</td>
<td>6.65</td>
</tr>
<tr>
<td></td>
<td>Not science related</td>
<td>29</td>
<td>38.76</td>
<td>5.49</td>
</tr>
<tr>
<td>Surface Approach</td>
<td>Control</td>
<td>15</td>
<td>32.13</td>
<td>4.58</td>
</tr>
<tr>
<td></td>
<td>Not science related</td>
<td>34</td>
<td>33.71</td>
<td>5.70</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>8</td>
<td>29.63</td>
<td>5.01</td>
</tr>
<tr>
<td></td>
<td>Not science related</td>
<td>29</td>
<td>33.55</td>
<td>6.14</td>
</tr>
</tbody>
</table>

Note. The mean possible score range was 11–55 for each category, deep and surface, with the higher scores relating to more of a tendency to use that approach.

Table 15 reveals that, for both control and experimental groups, the means for the deep approach to learning appear higher than the means for surface approach to learning. Also, the means for the different approach scores and student academic major did not appear to show a trend. SPSS (Version 22.0) was used to perform a MANOVA to determine statistical significance between the student approach to learning scores and their academic majors, and the multivariate test showed no significance, Pillai’s Trace = 0.02, $F(2, 81) = 0.69$, $p = 0.50$. These findings indicate that neither the course format
(online or face-to-face) nor the student academic major played a role in student preferred approach to learning.

Ancillary Findings

There were a few other findings that emerged from this data that should be mentioned, although they may not have been significant or may not have been part of an original research question. First, student perceptions of instructor support were not found to affect student approach to learning, nor were they found to differ between the online and face-to-face student populations. These findings indicate that the instructor support for the two different course formats may have been very similar. Second, although not found to significantly differ between the two course formats, there were higher means for student perceptions of active learning and student autonomy in the online student population. Third, the original deep approach score was actually higher for the online student population, even though the original approach scores were not found to significantly differ. There was also no significance found for the change in approach scores; however, more of the participants in the control group rather than the experimental group had an increase in deep approach scores and surface approach scores (Figure 7).
Fourth, although no significance was found between the posttest scores of the two groups or between the means for the entrance exam to a subsequent science course, the online students actually had higher means for each except for the Unit 4 posttest. Finally, the attrition rate for the participants in the experimental group was 25% while only 14% in the control group. The importance and implications of these ancillary findings will be discussed in Chapter V.

**Summary**

This study contained seven research questions pointed towards understanding the relationship between transactional distance, approach to learning, course format, and knowledge outcomes in online and face-to-face General Biology I with Lab courses offered at a southern community college. Research questions one and four were analyzed by determining Pearson correlations. Research questions two, three, five, and seven were analyzed by MANOVAs. Research question six was analyzed by performing an
independent $t$-test. The findings in this study indicated that transactional distance did affect the students’ deep approach scores but had no effect on the surface approach scores. Also, the transactional distance only differed in the category of student interaction between the online and face-to-face groups. However, there was no significance found when comparing the original approach (deep or surface) and the chosen course format, nor between the knowledge outcomes between the two groups. Also, no significance was found for the correlation between approach to learning and student major nor in the transactional distance’s effect on the change in approach to learning scores from the beginning of the semester to the end of the semester. Therefore, research hypotheses one and two were supported, while research hypotheses three, four, five, six, and seven were not. Overall, these findings indicate that, for these particular participants, the experience and outcomes for online and face-to-face biology students were similar. Ancillary findings deemed to be important were also discussed and will be further examined in Chapter V.

Chapter V presents the findings, conclusions, and implications of this study concerning online and face-to-face courses in the biological sciences. Recommendations for instructors at community colleges are presented to help them determine best teaching practices. Suggestions for future research to expand upon this study will also be offered.
CHAPTER V
DISCUSSION

This chapter contains a summary of this study and the results that have been found after data collection. Conclusions formed from the results of this study are discussed. The limitations of this study are presented to help readers understand why results may have been affected. Recommendations for future research and possible implications of this study are addressed to provide readers with an overview of how to expand and utilize the results from this study.

Summary of the Study

The purpose of this study was to determine whether there was a difference in the transactional distance, approach to learning, and knowledge outcomes between online General Biology I with Lab students and face-to-face General Biology I with Lab students. The relationship between the approach to learning and transactional distance were also examined, as well as the relationship between approach to learning and student academic major. Several statistical analyses were used to determine the differences between the approach to learning, transactional distance, and knowledge outcomes of the online and face-to-face groups. Approach to learning (deep or surface) was measured with the Revised Student Learning Process Questionnaire. Transactional distance was measured with the Distance Education Learning Environments Survey. Finally, knowledge outcomes were measured with four unit pretests and posttests, as well as the entrance exam to a subsequent science course.

Description of Sample Participants

The participants in this study were chosen solely on their enrollment in the online and face-to-face General Biology I with Lab courses offered at a southern
community college. The age, race, ethnicity, past experience online, science background, nor any other factors about the individuals were used to determine whether a participant was asked to be a part of the study. There were a total of 86 participants; however, not all of them participated in every aspect of the study.

Description of Study Variables

There were several variables in this study, including approach to learning, transactional distance, student major, and student content knowledge. In order to collect information about student approach to learning (deep and surface), the R-LPQ-2F was given to each participant. In order to collect student perceptions of transactional distance, each participant was given the DELES. To gather information about student knowledge outcomes, four unit pretests and posttests and an entrance exam to a subsequent science course were given to each participant.

The questionnaires, pretests, posttests, and the entrance exam to subsequent science courses were all given through Qualtrics (Qualtrics, Provo, UT), and all participants used a pin number instead of their names in order to identify themselves. A research associate gathered all pin numbers associated with names of participants and kept them in a secure location away from the researcher and the instructors of the course until after grades were submitted at the end of the course.

The R-LPQ-2F consisted of 22 questions that measured a student’s approach to learning. Eleven of the questions were designed to measure the deep approach score, while the other 11 were designed to measure the surface approach score. The questionnaire was administered to participants at the beginning of the semester in order to determine student approach to learning scores (deep and surface) before the class began. These deep and surface scores were also used to determine whether the initial approach to
learning was related to a student’s academic major. The R-LPQ-2F was administered again at the end of the semester in order to determine whether there was a change in deep and surface approaches as well as a relationship between the approach to learning and feelings of transactional distance. The students were asked to rate the individual questions based on the following scale: 1 = *This item is never or only rarely true of me*, 2 = *This item is sometimes true of me*, 3 = *This item is true of me about half of the time*, 4 = *This item is frequently true of me*, 5 = *This item is always or almost always true of me*.

The DELES was comprised of 34 questions divided into six categories: instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy. This survey was designed to determine a student’s perceptions about each category in order to give an idea of the transactional distance felt for the course. This survey was distributed to participants near the end of the study in order to get the best representation of the perceptions of each category for this specific course. Each category was rated by the students with the following scale: 1 = *Never*, 2 = *Seldom*, 3 = *Sometimes*, 4 = *Often*, 5 = *Always*.

The pretests and posttests for each of the four units were given in order to determine student knowledge outcomes. The four pretests were administered at the beginning of the course, while each pretest was administered at the end of each respective unit. Unit 1 contained questions about the chemistry and biological molecules. Unit 2 contained questions about genetics. Unit 3 contained questions about the cell and cell membrane. Unit 4 contained questions about cellular respiration and photosynthesis. Each pretest was made of 10 questions about the content within the unit, and each posttest was made of the same questions as the specific unit pretest.
Analysis of Research Questions and Hypotheses

Research Question One

Is there a relationship between students’ perceptions of transactional distance and their preferred approaches to learning (deep versus surface)?

It was hypothesized that there would be a significant relationship between the scores of instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy and the students’ scores for deep and surface approaches to learning. This hypothesis was only partially supported by the findings of this study as no significant correlation was found between the deep approach scores and the scores for instructor support and learner autonomy. Also, no significant correlation was found between the surface approach scores and any of the DELES categories. Statistical analysis revealed that there were significant correlations between the deep approach scores of participants and their scores for student interaction, personal relevance, authentic learning, and active learning categories of the DELES. As students’ perceptions of each of these categories in the biology classes went up, so did their desires for a deep learning approach. This study indicated that deep learning approaches were taken when students felt that interaction with peers was sufficient, when they felt the course was personally relevant, and when the learners were provided authentic examples and active learning opportunities. There was no significant correlation with any of the categories of transactional distance and the surface approach to learning, however.

Trigwell et al. (1999) stated that the learning environment may influence the approach to learning. The specific aspects of the learning environment, in this case, were student interaction, personal relevance, authentic learning, and active learning. Floyd et
al. (2009) stated that a positive learning environment was one that had perceived value, provided engagement, and promoted deeper learning strategies. The findings here support those findings and give the idea that the students may have perceived the course formats, both online and face-to-face, as a positive learning environment. This study also adds to the body of knowledge provided by several studies about how student interaction is a factor in the development of a positive learning environment by decreasing transactional distance and increasing student success (Berge, 1999; Chen, 2001; Lee & Rha, 2009; Liaw & Huang, 2000; Mawn et al., 2011; McBrien et al., 2009; Moore, 1989; Northrup, 2001; Walker & Fraser, 2005). This increase in student success may be due to the decreased feelings of isolation a learner may feel when interactions between learners take place (Northrop, 2001; Palloff & Pratt, 1999).

Engagement and course value have also been found to be important for the promotion of deep learning strategies (Floyd et al., 2009, Harlen & Doubler, 2004; Lin et al., 2012; Mickle & Aune, 2008; Mawn et al., 2011; Reeves & Kimbrough, 2004; Svirko & Mellanby, 2008). The correlations between a student’s deep approach to learning and the transactional distance categories of personal relevance, authentic learning, and active learning support these previous findings.

Research Question Two

Does the transactional distance perceived by online biology courses differ from the transactional distance perceived by students in face-to-face biology courses?

It was hypothesized that there would be a significant difference in the means of each of the DELES categories between the online and face-to-face biology students. This hypothesis was only partially supported as the only category found to be significantly different between the two groups was that of student interaction. While instructor
support, student interaction, personal relevance, and authentic learning seemed to differ between the control and experimental groups with higher scores in the control group, a significant difference between the means of these category scores was only found for student interaction. The students in the control group (face-to-face) perceived more student interaction than the students in the experimental group (online). Although not statistically significant, instructor support, personal relevance, and authentic learning had higher means in the control group while active learning and student autonomy had higher means in the experimental group. The findings for this particular research question suggest that the online students felt they had a similar experience with the course to their face-to-face counterparts. These findings are supported by McIsaac and Gunawardena (1996) that the increase in the technological abilities has allowed instruction to be more similar for online and face-to-face courses. While both formats may have been perceived as positive learning environments (engagement, relevance, and deep approaches), the face-to-face may have actually been perceived as more of a positive learning environment due to higher student interaction scores.

**Research Question Three**

Is there a significant difference between the original approach to learning (deep versus surface) taken by students in online biology courses versus those students in face-to-face biology?

It was hypothesized that there would be a significant difference in the original approach to learning (deep versus surface) between the online and face-to-face biology students. Initially, it appeared that the online students had higher deep approach scores and lower surface approach scores than the face-to-face students; however, statistical analysis revealed that there was no significant difference between the control and
experimental groups’ deep and surface scores. The findings from this study did not support this hypothesis; therefore, it was rejected.

Research Question Four

Does transactional distance promote a change in approach to learning (deep versus surface) from the beginning of the semester to the end of the semester?

It was hypothesized that there would be a significant relationship between each of the DELES category scores and the difference in the deep approach scores from the beginning of the semester to the end. It was also hypothesized that the same would occur for surface approach scores. Statistical analysis revealed that there was no significance between the difference in a student’s deep approach score from beginning to end of the semester nor in the difference in surface approach score from beginning to end of the semester when compared to the categories of transactional distance. This indicated that transactional distance did not affect the change in approach to learning. These findings did not support the hypothesis; therefore, it was rejected.

Research Question Five

Do online biology students’ pretest and posttest scores differ from pretest and posttest scores of students in face-to-face biology courses?

It was hypothesized that a significant difference would be found in the differences in the means of unit posttest scores between the online biology students and the face-to-face biology students. Statistical analysis of the posttest scores for each unit for each group revealed that there was no significant difference between the groups; therefore, the hypothesis was not supported by this study. An evaluation of the differences between the calculated means of the pretests and posttests did reveal that there were knowledge gains for each unit and in each group: online and face-to-face.
Research Question Six

Do online biology students score as well as face-to-face biology students on an entrance exam to a subsequent science course for which biology is a prerequisite?

It was hypothesized that there would be a significant difference between the scores of the subsequent science course entrance exam of online biology and face-to-face biology students. The findings in this study did not support this hypothesis as no significant difference was found for the scores between the groups. These findings indicate that the groups of students seemed to be equally prepared for the next level science course. Closer analysis of the means for this exam for each group revealed that the online group had a higher mean score.

Research Question Seven

Is there a difference between the approaches to learning (deep versus surface) for a student in a science or health-related field when compared to the approaches to learning of students in other majors?

It was hypothesized that there would be a significant difference in the approach to learning (deep versus surface) scores for students claiming a major other than those related to science or health-related fields whether enrolled in online or face-to-face biology courses when compared to students that claim a science or health-related major. The findings of this study did not support this hypothesis. The statistical findings were not significant, indicating that the choice of major did not influence the deep or surface approach to learning scores for students in this study.

Ancillary Findings

There were a few very interesting findings that were either deemed nonsignificant or were not part of an original research question. First, while many of these findings
support previous literature, there were some that emerged from this study that defy previous literature. For example, instructor support was not found to be significantly different between the two course formats nor was it found to be significant for a deep learning approach. This indicates that the students in the control and experimental groups of this specific study felt a very similar presence by the instructor but did not feel that the instructor support was as necessary for a deep approach as student interaction, personal relevance, authentic learning, and active learning.

Second, the means for student perceptions of active learning and student autonomy were the only DELES categories that were higher for the online students than the face-to-face students. This finding supports previous literature states that online learners often have higher autonomy than face-to-face students (Moore, 1973). Also, the original deep approach score was higher for the online students than for the face-to-face students. Previous literature states that online students often have higher deep approach scores than the face-to-face courses (Quinn, 2011). The higher deep approaches, higher perceptions of active learning, and higher perceptions of student autonomy may have led to another nonsignificant, yet interesting finding, that the online students actually had higher means for the posttests for Units 1–3 and the entrance exam to a subsequent science course. These stronger feelings for deep knowledge and responsibility for their own learning may also have made an impact on how they perceived the importance of instructor support.

Third, although there was no significance in the change in approach score when compared to transactional distance, the number of participants with increased deep approach scores was much higher in the control group versus the experimental group. For at least half of the face-to-face students, the deep approach and surface approach
increased. Specifically, the deep approach increased for 50% of the participants while the surface approach increased for 59% of the participants. While a high score for a deep approach is ideal, both types of approaches are necessary for learning, depending on the task at hand. Therefore, the increase in surface scores for over half of the face-to-face students does not necessarily represent a shift to “survival mode.” Far fewer online student participants’ deep approach scores increased; however, the increase in surface approach scores was very similar to that of the increase seen in face-to-face students. Only 33% of the online participants’ deep approach scores increased, while 56% of the participants’ surface approach scores increased. The higher percentage of participants with increased deep approach scores combined with the significant finding from research question two that student interaction was perceived more by face-to-face students, support previous literature stating that student interaction may lead to an increased desire for deep learning strategies (Mawn et al., 2011).

Finally, there was a 25% attrition rate for online student participants. This may support previous literature that online students often ignore material that does not seem relevant for a passing grade as they shift to “survival mode.” The large percentage of online students who had an increase in surface approach scores may support this.

Implications for Policy and Practice

The results of this study could impact online education by adding to previous research about student perceptions of transactional distance and approach to learning, as well as their impacts on student knowledge outcomes. The outcomes of this study indicate that student interaction and collaboration, personal relevance, authentic learning, and active learning are important for a student’s desire for deeper learning strategies. This was supported by many other studies, as mentioned above; however, the fact that no
correlation was found between instructor support and deep or surface learning strategies was not. Most previous findings indicate that instructor support is paramount for a decrease in transactional distance (Berge, 1999; Moore, 1989), which is believed to be necessary for an increase in deeper learning strategies. Also, studies about learner autonomy are lacking (Chen & Willits, 1998), and these findings do not fully support Moore’s (1973) notion that online students have higher learner autonomy since the means were slightly higher between the groups, but no significance was found.

This study’s findings that the categories of student interaction and collaboration, personal relevance, authentic learning, and active learning led to deeper learning approaches support previous findings; thus, it is important that instructors try to incorporate these into the online learning environment. This would help build a positive learning environment, which is so necessary in order to attract students (Floyd et al., 2009) and increase student knowledge. These should be incorporated into both the online and the face-to-face learning formats, because while knowledge outcomes were similar for both groups in this study, they were neither impressive nor representative of subject mastery.

Better immersion of student-student interaction within the online learning environment may lead to less isolation (Northrup, 2001; Palloff & Pratt, 1999), which may promote more contact with course materials leading to better learning outcomes, increased satisfaction, decreased transactional distance, and increased retention (Liaw & Huang, 2000). One way to incorporate student-student interaction is through the creation of discussion forums and collaborative projects where online students are assigned to work in groups. While this discussion occurs in the laboratory or classroom in the face-to-face setting, it can occur through discussion boards, emails, and video chats for those
in online learning environments. Another possibility for student-student interaction is through discussion board study group sessions. Each student could have the option to post questions or concerns about the course content, as well as offer explanations, extra resources, or study techniques that may help classmates. The opportunity for students to engage in active learning was also found to promote deep learning strategies for the students in this study. The incorporation of student-student collaborative activities similar to these not only supports peer communication and connectedness, but also active learning opportunities in an otherwise passive learning environment. These opportunities are especially important for courses offered within the community college setting where many of the students may be nontraditional and may not have the opportunity for meeting a class face-to-face.

Because personal relevance and authentic examples were also found to promote deep learning, courses should offer content that includes material the students feel is relevant to either their future careers or their personal lives. This is especially the case in the community college setting where obstacles faced by nontraditional students may lead to increased student dropout rates and decreased student success rates. By using examples that help students to apply knowledge to whatever nontraditional situations that they may be facing (dependents, age, health, work, etc.), an instructor may be able to increase the likelihood for success and course completion for those students.

The comparable knowledge outcomes found within this study give some promise to online learning in biology. These findings are important because, thus far, research in this area is lacking. In addition, the transferability and credibility of the online courses offered by community colleges must be maintained in order for students to make a smooth transition to the next level. The idea that online learners only learn passively and
in isolation has led to the idea that online learning quality is questionable (Hara & Kling, 2000). While results of this study are only generalizable to the participants within this study, a long-term study including demographic data may help to add to previous and future findings in order to ease concerns about online learning quality. Also, because a student’s declared major seemed to have no effect, a long-term study may give insight as to whether these results could be somewhat generalizable, and therefore, applicable to all online courses and not only biology.

Limitations

The participants within this study were limited to General Biology I with Lab students at a southern community college during the summer 2014 semester, so these results may not be able to be generalized beyond this sample. The summer semester student population usually varies from fall and spring semester student populations due to several factors. For example, there may have been an increased population of traditional students due to students that returned home from four-year institutions for summer but continued to take courses through the break. Demographics may have affected the results of this study; however, there was no examination of that data. Further limitations included honesty and accuracy with answering the questions provided in all of the instruments. Because these were not graded for accuracy, nor proctored, students may have hurriedly and carelessly answered or may have used notes or other resources when instructed not to do so. Finally, while enough participants completed the instruments in order to maintain a power necessary for valid results, data could have been skewed by the attrition rate in the number of participants for each instrument as not all participants completed all parts of the study.
Recommendations for Future Research

While distance education courses have been on the rise in most educational institutions, there is a special place for this type of learning in the community college setting due to the unique student population enrolled (Kadlubowski, 2000). This study is promising to demonstrate that online and face-to-face science courses may have equal outcomes, especially when research in this area has been lacking and when there are concerns by many educators and institutions about online learning quality.

The first recommendation is to conduct this study on a much larger sample size that is more representative of the overall community college population as this sample only contained 87 students. Also, conducting the study over a longer time period in order to include students in all semesters due to differences between the types of students that take courses each semester, especially summer, would be ideal.

The second recommendation is to test the students’ knowledge gains in a proctored situation, and possibly in a manner that the student may feel it is important to answer questions as accurately as possible. This would give a better outlook on the actual knowledge gains between the groups.

A third recommendation would be to conduct this study with pretests and posttests that include more cognitive learning tasks. This may help measure actual deep knowledge versus the preference for deep knowledge.

A fourth recommendation would be to analyze the perceptions of transactional distance, approach to learning and compare knowledge outcomes of the students within the 4 week face-to-face course and the 10 week face-to-face course. This may help to determine whether time is a factor in student perceptions and knowledge outcomes and
could help to paint a much more detailed picture of what actually is most important for developing or changing them.

A final recommendation would be to perform a qualitative analysis on the participants in the study. Quantitative analysis sometimes does not offer the complete story, as the researcher is unaware of the reasons given behind individual choices on surveys. A large part of this study focused on the perceptions and preferences for different variables, so a qualitative analysis would be an excellent follow-up in order to understand more about how students actually learn and interact in the science courses, regardless of delivery method.

The purpose of this study was to determine student perception of transactional distance, approach to learning, and knowledge outcomes between online and face-to-face biology students. Further research on this topic is important because so little is available for the sciences, especially at the undergraduate level. While the knowledge outcomes between the online and face-to-face groups were not found to be significantly different from each other, these findings, in addition to future studies, may lead to decreased concerns of online learning quality. Also, implementation of the suggestions presented in this study may benefit community college online biology students and help ensure equal opportunity for education.
APPENDIX A

R-LPQ-2F QUESTIONNAIRE

Revised Learning Process Questionnaire (R-LPQ-2F)
© 2001 John Biggs and David Kember
(*Amended only to reverse the order of answer choices in order to parallel those of the DELES.)

This questionnaire has a number of questions about your attitudes towards your studies and your usual way of studying. There is no right way of studying. It depends on what suits your own style and the course you are studying. It is accordingly important that you answer each question as honestly as you can. If you think your answer to a question would depend on the subject being studied, give the answer that would apply to biology.

Please choose the most appropriate answer. The letters alongside each number stand for the following response.

A — this item is never or only rarely true of me
B — this item is sometimes true of me
C — this item is true of me about half the time
D — this item is frequently true of me
E — this item is always or almost always true of me

Do not spend a long time on each item: your first reaction is probably the best one. Please answer each item. Do not worry about projecting a good image. Your answers are CONFIDENTIAL. Thank you for your cooperation.

(1) I find that at times studying makes me feel really happy and satisfied.
(2) I try to relate what I have learned in one subject to what I learn in other subjects.
(3) I am discouraged by a poor mark on a test and worry about how I will do on the next test.
(4) I see no point in learning material which is not likely to be in the examination.
(5) I feel that nearly any topic can be highly interesting once I get into it.
(6) I like constructing theories to fit odd things together.
(7) Even when I have studied hard for a test, I worry that I may not be able to do well in it.
(8) As long as I feel I am doing enough to pass, I devote as little time to studying as I can. There are many more interesting things to do.
(9) I work hard at my studies because I find the material interesting.
(10) I try to relate new material, as I am reading it, to what I already know on that topic.
(11) Whether I like it or not, I can see that doing well in school is a good way to get a well-paid job.
(12) I generally restrict my study to what is specifically set as I think it is unnecessary to do anything extra.
(13) I spend a lot of my free time finding out more about interesting topics which have been discussed in different classes.
(14) When I read a textbook, I try to understand what the author means.
(15) I intend to get my A Levels [or equivalent qualification] because I feel that I will then be able to get a better job.
(16) I find it is not helpful to study topics in depth. You don’t really need to know much in order to get by in most topics.
(17) I come to most classes with questions in mind that I want answering.
(18) I learn some things by rote, going over and over them until I know them by heart even if I do not understand them.
(19) I find I am continually going over my school work in my mind at times like when I am on the bus, walking, or lying in bed, and so on.
(20) I find the best way to pass examinations is to try to remember answers to likely questions.
(21) I like to do enough work on a topic so that I can form my own conclusions before I am satisfied.
(22) I find I can get by in most assessment by memorizing key sections rather than trying to understand them.
APPENDIX B

DISTANCE EDUCATION LEARNING ENVIRONMENTS SURVEY

*Without Enjoyment category questions

This survey contains 34 statements about practices that take place in this class.

There are no 'right' or 'wrong' answers. Your opinion is what is wanted on each item. Please think about how well each statement describes what this class is like for you.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Never</th>
<th>Seldom</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. If I have an inquiry, the instructor finds time to respond.</td>
<td></td>
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<tr>
<td>2. The instructor helps me identify problem areas in my study.</td>
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<tr>
<td>3. The instructor responds promptly to my questions.</td>
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<tr>
<td>4. The instructor gives me valuable feedback on my assignments.</td>
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<tr>
<td>5. The instructor adequately addresses my questions.</td>
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<td>6. The instructor encourages my participation.</td>
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<td>7. It is easy to contact the instructor.</td>
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<tr>
<td>8. The instructor provides me positive and negative feedback on my work.</td>
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<tr>
<td>9. I work with others.</td>
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<tr>
<td>10. I relate my work to other's work.</td>
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<tr>
<td>11. I share information with other students.</td>
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<td></td>
</tr>
<tr>
<td>12. I discuss my ideas with other students.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>13. I collaborate with other students in the class.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>14. Group work is a part of my activities.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>15. I can relate what I learn to my life outside of university.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>16. I am able to pursue topics that interest me.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>17. I can connect my studies to my activities outside of class.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>18. I apply my everyday experiences in class.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>19. I link class work to my life outside of university.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>20. I learn things about the world outside of university.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>21. I apply my out-of-class experience.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>22. I study real cases related to the class.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>23. I use real facts in class activities.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>24. I work on assignments that deal with real-world information.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>25. I work with real examples.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>26. I enter the real world of the topic of study.</td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Often</td>
<td>Always</td>
</tr>
</tbody>
</table>
27. I explore my own strategies for learning.

28. I seek my own answers.

29. I solve my own problems.

30. I make decisions about my learning.

31. I work during times I find convenient.

32. I am in control of my learning.

33. I play an important role in my learning.

34. I approach learning in my own way.
APPENDIX C

PERMISSION TO USE THE DISTANCE EDUCATION ENVIRONMENTS SURVEY

Barry Fraser < B.Fraser@curtin.edu.au>  
To: Erin Riggins <mary.erin.riggins@gmail.com>  
Sun, Oct 27, 2013 at 11:06 PM

Erin

Scott Walker has moved to another university, but I don't remember which one.

You have my permission to use DELES.

For a comprehensive and recent review of research on learning environments, see B.J. Fraser, K.G. Tobin and C.J. McRobbie (Eds.), Second International Handbook of Science Education (pp. 1191-1229). New York: Springer.

Good luck with your research.

Barry Fraser

Dr Barry J Fraser  
FIAE FTSE FASSA FAAAS FAERA FACE  
John Curtin Distinguished Professor  
Director | Science and Mathematics Education Centre  
Associate Dean | Graduate Studies | Science and Engineering

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[Quoted text hidden]
APPENDIX D

UNIT 1 PRETEST AND POSTTEST—CHEMISTRY AND BIOLOGICAL MOLECULES

Instructions: Please choose the answer that best fits each question. These answers will not count against your grade.

1. Which of the following is the most inclusive level of organization?
   a. subatomic particles  
   b. population  
   c. organ system  
   d. community

2. Scientific theories can become laws when
   a. enough experimentation has been done to prove the theory correct.  
   b. they are theories that describe natural phenomenon.  
   c. a certain amount of the scientific community agrees that the theory will most likely not be disproven.  
   d. None of these answers are true as theories cannot become laws.

3. The level of organization that includes the living and the nonliving components of an area is
   a. populations  
   b. ecosystems  
   c. communities  
   d. organ systems

4. When metals bond with nonmetals, they form which type of bond?
   a. hydrogen  
   b. nonpolar  
   c. covalent  
   d. ionic

5. All of the following are carbohydrates except
   a. starch  
   b. glucose  
   c. sterol  
   d. ribose

6. Lipids are
   a. hydrophilic  
   b. polar  
   c. hydrophobic  
   d. inorganic

7. Which of the following best describes the definition of organic molecules?
   a. Molecules that make up living things  
   b. Carbon-based molecules  
   c. Molecules that have carbons in chain or ring structures  
   d. Molecules composed of a metal and a nonmetal

8. Which of the following is NOT a property of living things?
   a. All living things perform metabolism.  
   b. All living things have DNA.  
   c. All living things have a nucleus to surround DNA.  
   d. All living things are composed of the same basic molecules: carbohydrates, lipids, proteins, and nucleic acids.
9. DNA is
   a. a protein. 
   c. a lipid 
   b. a carbohydrate 
   d. a nucleic acid 

10. Atoms of certain elements bond because of attractions between 
    a. protons 
    c. electrons 
    b. neutrons 
    d. quarks
APPENDIX E
UNIT 2 PRETEST AND POSTTEST – GENETICS

Instructions: Please choose the answer that best fits each question. These answers will not count against your grade.

1. How many chromosomes should a human have?
   a. 28  
   b. 23  
   c. 46  
   d. 92

2. Nucleic acids are made of
   a. nucleotides  
   b. amino acids  
   c. proteins  
   d. carbohydrates

3. Which sugar is found in DNA?
   a. glucose  
   b. ribose  
   c. sucrose  
   d. deoxyribose

4. Which is a correct bonding pattern for the nitrogenous bases found in DNA?
   a. A-T  
   b. A-U  
   c. C-A  
   d. G-T

5. The type of cell division that occurs for growth and repair of a human is
   a. meiosis  
   b. hydrolysis  
   c. mitosis  
   d. binary fission

6. The parent cell of meiosis is a
   a. gamete  
   b. germ cell  
   c. egg cell  
   d. somatic cell

7. The parent cell of mitosis is a
   a. gamete  
   b. germ cell  
   c. egg cell  
   d. somatic cell

8. At the end of mitosis, there are ____________ of chromosomes in the daughter cell as the parent cell.
   a. half the number  
   b. the same number  
   c. ¼ of the number  
   d. double the number

9. During which process is mRNA made?
   a. DNA replication  
   b. translation  
   c. glycolysis  
   d. transcription

10. What are the building blocks of proteins?
    a. amino acids  
    b. nucleotides  
    c. glucose  
    d. nucleic acids
APPENDIX F

UNIT 3 PRETEST AND POSTTEST – THE CELL AND CELL MEMBRANE

Instructions: Please choose the answer that best fits each question. These answers will not count against your grade.

1. Which of the following organelles is responsible for producing energy?
   a. golgi body
   b. nucleus
   c. mitochondrion
   d. rough ER

2. Which of the following organelles is a location for protein production?
   a. golgi body
   b. smooth ER
   c. mitochondrion
   d. rough ER

3. Which of the following organelles houses the DNA?
   a. golgi body
   b. rough ER
   c. mitochondrion
   d. nucleus

4. What makes up the cell membrane?
   a. carbohydrates
   b. phospholipids
   c. glucose
   d. cellulose

5. Which of the following organelles is believed to have once been a single – celled organism engulfed by a larger cell?
   a. golgi body
   b. nucleus
   c. mitochondrion
   d. rough ER

6. Which cellular machine is responsible for recycling and replacing parts of the cell that are not working correctly?
   a. lysosomes
   b. peroxisomes
   c. ribosomes
   d. endosomes

7. Which of the following exist within the cell membrane and serve to transport specific things into or out of the cell?
   a. carbohydrates
   b. proteins
   c. phospholipids
   d. nucleotides

8. Which of the following does not require energy?
   a. active transport
   b. facilitated transport
   c. endocytosis
   d. exocytosis

9. Which of the following types of cells does not have a nucleus?
   a. eukaryotic
   b. animal
   c. plant
   d. prokaryotic

10. Which of the following does not have a cell wall?
    a. plant
    b. animal
    c. bacteria
    d. All of these have cell walls.
APPENDIX G

UNIT 4 PRETEST AND POSTTEST – CELL RESPIRATION AND PHOTOSYNTHESIS

Instructions: Please choose the answer that best fits each question. These answers will not count against your grade.

1. ______________ serve as catalysts to metabolic reactions within the cells.
   a. Amino acids  
   b. carbohydrates  
   c. enzymes  
   d. mitochondria

2. Cellular respiration is the production of _____________ from glucose.
   a. ATP  
   b. ADP  
   c. polysaccharides  
   d. AMP

3. Which of the following is not associated with photosynthesis?
   a. chloroplast  
   b. thylakoid  
   c. stroma  
   d. large central vacuole

4. Which of the following is not associated with cellular respiration?
   a. cytoplasm  
   b. golgi body  
   c. mitochondria  
   d. electron transport chain

5. The final acceptor of electrons at the end of the electron transport chain is
   a. hydrogen  
   b. oxygen  
   c. NAD+  
   d. NADP+

6. During cellular respiration, a higher concentration of _____________ must be formed in the outer membrane of the mitochondrion.
   a. hydrogen  
   b. oxygen  
   c. NAD+  
   d. NADP+

7. During the light reaction of photosynthesis, which of the following is not involved?
   a. H2O (water)  
   b. sunlight  
   c. thylakoids  
   d. CO2 (carbon dioxide)

8. During the dark reaction of photosynthesis, which of the following is not involved?
   a. thylakoid  
   b. stroma  
   c. CO2 (carbon dioxide)  
   d. ATP

9. Glucose is formed during the
   a. Krebs Cycle  
   b. Calvin Cycle  
   c. light reaction  
   d. electron transport chain

10. Which of the following best describes the metabolism that occurs in the absence of oxygen?
    a. deoxygenated  
    b. aerobic  
    c. anaerobic  
    d. electron transport phosphorylation
APPENDIX H

ENTRANCE EXAM TO SUBSEQUENT SCIENCE COURSE

Instructions: Please choose the answer that best fits each question. These answers will not count against your grade.

1. The energy unit most often used as the unit to measure energy in living things is:
   a. Joule   b. erg   c. BTU   d. kilocalorie

2. _______________ are proteins that serve as biological catalysts.
   a. DNA   b. ATP   c. lecithin   d. enzymes   e. plasmodesmata

3. _______________ metabolism refers to biochemical pathways in which larger, more complex molecules are broken down into smaller, less complex molecules.
   a. Aerobic   b. catabolic   c. condensation   d. anabolic

4. An enzyme is named generally by adding _______________________
   a. “ose” to the name of the cell in which it is found.
   b. “ase” to the name of the cell in which it is found.
   c. “ose” to the end of the name of the substrate.
   d. “ase” to the end of the name of the substrate.
   e. “ase” to the end of the name of the co-enzyme.

5. Which of the following statements regarding enzymes is correct?
   a. The more an enzyme is heated, the more active it becomes.
   b. Enzymes are composed of monosaccharides.
   c. Enzymes are unaffected by the concentration of H ions.
   d. An enzyme’s function is directly related to its 3-D shape.
   e. All of the preceding statements regarding enzymes are correct.

6. The net movement of molecules from a region of higher concentration to a region of lower concentration is
   a. Active transport
   b. Phagocytosis
   c. Exocytosis
   d. Pinocytosis
   e. Diffusion

7. The movement of molecules from a region of lower concentration to higher concentration across a plasma membrane, utilizing a transport protein is called
   a. Pinocytosis
   b. Passive transport
   c. Active transport
   d. Phagocytosis
   e. Osmosis
8. Which of the following BEST describes the structure of the cell membrane?
   a. Solid, rigid layer of phospholipids with loosely bound protein particles
   b. Bilayer of phospholipid molecules in which protein molecules are embedded
   c. Strong layers of protein molecules where carbohydrate molecules float freely
   d. Tri-layer in which lipids are on the inside, proteins are on the middle, and carbohydrates are on the outside
   e. Bilayer of protein molecules in which carbohydrate molecules are embedded

9. Whether a substance can cross the membrane of a cell depends on
   a. the size of the particles.
   b. the electrical charge of the particles.
   c. the molecular makeup and arrangement of plasma membrane.
   d. the chemical properties of the substance.
   e. all of the preceding answers.

10. The energy needed to move substances across a cell membrane against a concentration gradient is supplied by
   a. cAMP  b. heat  c. light  d. ATP  e. DNA

11. __________________________ compounds are those that have the element carbon bonded to hydrogen and possible other substances.
   a. Inorganic  b. acidic  c. ionic  d. organic  e. fortified

12. A(n) ______________ reaction is a type of chemical reaction in which less complex molecules are bonded together to form larger, more complex molecules.
   a. Hydrolysis
   b. digestion
   c. catabolism
   d. deesterification
   e. condensation

13. Carbohydrates
   a. Contain carbon, hydrogen, nitrogen, and oxygen.
   b. Are involved in the storage and transmission of genetic information.
   c. Can be polymers composed of monosaccharides joined by peptide bonds.
   d. Contain carbon, hydrogen, and oxygen in a 1:2:1 ratio.
   e. None of the preceding are correct regarding carbohydrates.

14. __________________________ are building blocks (monomers) of proteins.
   a. Monosaccharides
   b. Fatty acids
   c. Amino acids
   d. Nucleotides
   e. Purines
15. ________________ are the type of chemical bonds that hold amino acids together.
   a. Ionic          b. glycosidic       c. ester        d. peptide       e. james
16. Sucrose, maltose, and lactose are examples of
   a. Monosaccharides
   b. Diglycerides
   c. Disaccharides
   d. Oligosaccharides
   e. Polysaccharides
17. ________________ is the disaccharide found in milk.
   a. Glucose       b. sucrose     c. lactose     d. maltose    e. raffinose
18. Sucrose is composed of
   a. Two molecules of glucose
   b. Two molecules of fructose
   c. A molecule of glucose and a molecule of fructose
   d. A molecule of fructose and a molecule of galactose
   e. Two molecules of galactose
19. Starches, cellulose, and glycogen are types of
   a. Disaccharides
   b. Dipeptides
   c. Polynucleotides
   d. Polypeptides
   e. Polysaccharides
20. _____ is the process of creating mRNA from DNA in the nucleus.
    a. DNA replication
    b. Transcription
    c. Translation
    d. Photosynthesis
21. _____ is the process of forming a protein on the ribosome.
    a. DNA replication
    b. Transcription
    c. Translation
    d. Photosynthesis
22. _____ is the process of creating 2 DNA molecules from one.
    a. DNA replication
    b. Transcription
    c. Translation
    d. Photosynthesis
23. _____ is the shape of DNA.
    a. Left handed double helix
    b. Left handed single helix
c. Right handed double helix
d. Right handed single helix

24. Adenine bonds to _____ in DNA.
   a. Adenine
   b. Cytosine
   c. Guanine
   d. Thymine

25. _____is the control center of the cell.
   a. Cytoplasm
   b. Endoplasmic reticulum
   c. Golgi apparatus
   d. Nucleus

26. _____are the organelles responsible for cellular respiration and are called the power houses of the cells.
   a. Endoplasmic reticulum
   b. Golgi apparatus
   c. Lysosome
   d. Mitochondria

27. _____is the jelly-like substance found in a cell outside of the nucleus.
   a. Cytoplasm
   b. Endoplasmic reticulum
   c. Golgi apparatus
   d. Mitochondria

28. _____is the tubular communication system found in the cell.
   a. Cytoplasm
   b. Endoplasmic reticulum
   c. Golgi apparatus
   d. Nucleus

29. _____is the organelle that is responsible for packaging proteins for secretion.
   a. Endoplasmic reticulum
   b. Golgi apparatus
   c. Mitochondria
   d. Nucleus

30. Which of the following makes energy from the sun available to all other forms of life?
   a. producers
   b. consumers
   c. decomposers

31. In mitosis, if a parent cell has 16 chromosomes, how many chromosomes will each daughter cell have?
   a. 64
   b. 32
   c. 16
32. At the end of meiosis I in corn (20 chromosomes), how many chromosomes will be present in the daughter cells?
   a. each cell has 20 chromosomes
   b. each cell has 10 chromosomes
   c. each cell has 40 chromosomes

33. What type of cell would contain chloroplasts, mitochondria, and a central vacuole?
   a. a prokaryote
   b. an animal cell
   c. a plant cell
   d. a fungus

34. If the DNA sequence is ACTGTA, which of the following correctly identifies the mRNA codons?
   a. AUG - CGU
   b. UAC - GCA
   c. UAG - CGU
   d. UGA - CAU
   e. ATG – CGT

35. Which of the following molecules carries out most of the functions of plasma membranes?
   a. cholesterol.
   b. proteins.
   c. phospholipids
   d. carbohydrates

36. A hormone would most likely bind to which membrane protein
   a. adhesion protein
   b. recognition protein
   c. receptor protein
   d. transport protein

37. This protein acts as a molecular fingerprint to identify tissues or individuals; it allows the body to determine if something is self or non-self.
   a. adhesion protein
   b. recognition protein
   c. receptor protein
   d. transport protein

38. Which is not an element?
   a. Water
   b. Oxygen
   c. Carbon
   d. Chlorine
   e. Hydrogen

39. In a chemical reaction, atoms can gain, lose, or share
   a. Neutrons
   b. Protons
c. Electrons

40. Which is the smallest unit of life that can exist as a separate entity?
   a. a cell
   b. a molecule
   c. an organ
   d. a population
   e. an ecosystem

41. The level of organization where factors such as sunlight, rainfall, and temperature enter the picture is the
   a. organ system.
   b. ecosystem.
   c. biosphere.
   d. molecule.
   e. community.

42. A scientific name consists of which of the following?
   I. family name
   II. genus name
   III. species name
   a. I only
   b. II only
   c. III only
   d. I and II
   e. II and III

43. The least inclusive of the taxonomic categories listed here is
   a. family.
   b. phylum.
   c. class.
   d. order.
   e. genus.

44. Which of the following are NOT eukaryotes?
   a. fungi
   b. bacteria
   c. plants
   d. animals
   e. protistans

45. The principal point of Darwin's theory of evolution by natural selection is that
   a. long-term heritable changes in organisms are caused by use and disuse.
   b. mutations that adapt an organism to a given environment always arise in
      the greatest frequency in the organisms that occupy that environment.
   c. mutations are caused by all sorts of environmental influences.
   d. survival of characteristics in a population depends on competition between
      organisms, especially between members of the same species.
   e. mutations mostly have favorable effects.

46. Prokaryotes
   a. have nucleoid regions.
b. are unicellular.
c. may have cell walls.
d. are either bacteria or archeans.
e. all of these

47. Photosynthesis is associated with all of the following **EXCEPT**
   a. chloroplasts.
   b. plastids.
   c. grana.
   d. thylakoid.
   e. vacuoles.

48. Which statement is true?
   a. A cell placed in an isotonic solution will swell.
   b. A cell placed in a hypotonic solution will swell.
   c. A cell placed in a hypotonic solution will shrink.
   d. A cell placed in a hypertonic solution will remain the same size.
   e. A cell placed in a hypotonic solution will remain the same size.

49. Metabolism describes
   a. the cell's capacity to acquire energy.
   b. cellular processes used to store substances.
   c. reactions that break apart nutrients to release energy.
   d. the elimination of waste products.
   e. all of these.
APPENDIX I

PERMISSION TO CONDUCT RESEARCH AT MISSISSIPPI GULF COAST COMMUNITY COLLEGE

Mississippi Gulf Coast Community College  
Request to Conduct Research at MGCCC

DIRECTIONS: Individuals who wish to conduct research utilizing MGCCC students or employees must complete this application and email to jason.pugh@mgccc.edu.

Purpose – This application must be completed and approval granted by the MGCCC Executive Council prior to conducting any research utilizing college students or employees. The purpose of this application is to ensure that the researcher complies with the following conditions:

(i) requires the researcher to summarize the proposed research and provide supporting documentation ensuring that research is performed in compliance with all applicable laws, regulations, and institutional and federal policies regarding human subjects research;

(ii) ensures the proposed research has institutional support or will have such support through IRB approval and the endorsement of a qualified research advisor (i.e., faculty member) who assumes responsibility for the project;

(iii) provides the applicant with appropriate documentation that the MGCCC Executive Council has reviewed the proposed study.

Principal Investigator (PI) Contact Information – The PI for the purposes of this application is the individual who will personally conduct this research study. Under most circumstances, the PI will be the student researcher.

Name: M. Erin Riggins  
Email: Erin.riggins@mgccc.edu  
Address: 2226 Switzer Rd.  
City: Gulfport  
State: MS  
Zip: 39507  
Phone: 228-897-3745

Research Advisor (RA) Contact Information – The RA for the purposes of this application is the individual who will personally supervise and oversee this research study. Under most circumstances, the RA will be the faculty member working with the student researcher.

Name: Dr. Sherry Herron  
Email: Sherry.herron@usm.edu  
Address:  
City:  
State:  
Zip:  
Phone: 601-266-5087

Sponsoring Institution or Agency:

Sponsoring Academic Division/Department:

Has the study obtained IRB approval from sponsoring institution?

☐ Yes, Approval Date ____________________________ If Yes, was Study ☐ Exempt or Expedited (deemed minimal risk to human subjects)
☐ No  
☐ Not Applicable, Explain: ☐ Full Board (deemed greater than minimal risk or work with special populations of human subjects)
APPENDIX J

THE UNIVERSITY OF SOUTHERN MISSISSIPPI AUTHORIZATION TO
PARTICIPATE IN RESEARCH PROJECT

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional-review-board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the “Adverse Effect Report Form”.
- If approved, the maximum period of approval is limited to twelve months. Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 14042802
PROJECT TITLE: Online vs Face-to-Face Biology: A Comparison of Student Transactional Distance, Approach to Learning, and Learning Outcomes
PROJECT TYPE: New Project
RESEARCHER(S): Mary Erin Riggins
COLLEGE/DIVISION: College of Science and Technology
DEPARTMENT: Science and Math Education
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 05/08/2014 to 05/07/2015

Lawrence A. Hosman, Ph.D.
Institutional Review Board
APPENDIX K

PERMISSION FROM INSTRUCTORS TO RECRUIT STUDENTS AND TO INCLUDE STUDY COMPONENTS AS COURSE REQUIREMENTS

April 21, 2014

Permission to Recruit Students

Upon IRB approval of “Online vs. face-to-face biology: A comparison of transactional distance, approach to learning and knowledge outcomes,” I give permission to recruit students from my BIO 1134 courses. I understand that the agreement or disagreement of my students to participate and the analysis of data collected throughout this course are completely voluntary. I am also aware that I will not be informed of specific responses from students participating in the study.

I understand that I can withdraw my permission to observe my course at any time throughout the project without repercussions.

Sincerely,
APPENDIX L

INFORMED CONSENT LETTER

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

AUTHORIZATION TO PARTICIPATE IN RESEARCH PROJECT

Consent is hereby given to participate in the study titled:
Student Perception of Transactional Distance and Approach to Learning in Community College Online Science Courses

**Purpose:** The purpose of this study is to attempt to determine the amount of engagement and involvement a student feels while enrolled in a course. It is also to determine the students’ approaches to learning in order to determine whether there is a relationship between a student’s perception of engagement, his or her approach to learning, and the learning outcomes.

Implications of this study include the ability to design more proficient online learning activities in order to improve satisfaction and deeper learning motives with students. This would, in turn, improve the ability to teach science online for sufficient knowledge gain and transfer to successive science courses. Community college students were chosen for this study because they are likely to have different obstacles that may stand in the way of learning and may be more likely forced into online classes due to these obstacles. For example, many of the students have full-time jobs and families at home. Research is lacking in the areas of online versus face-to-face science learning, student perception of science learning online, and student approach to learning science, so this study may improve upon the small amount of findings available to this date.

**Description of Study:** Quantitative data will be gathered through the use of specifically designed unit pretests, posttests, and questionnaires. Questionnaires will be given to the student to determine approach to learning and to determine the perception of engagement for this course. All pretests, posttests, and surveys will be given through a survey website, but the link to each will be posted in Canvas.

The students chosen for this research study include students from online and onsite biology courses at a southern community college.

**Benefits:** The students will gain a better insight into what types of learning activities are best for their particular learning styles. Data collected during this project may also lead to the development of online courses that are more customized to student learning types, more enjoyable to the students, and also better provide for deeper learning strategies. Better student satisfaction and more learning based on deep learning strategies may improve student construction of knowledge as well as the ability for transfer of knowledge to successive courses.
The students will receive entrance into a drawing for one of four $50 Visa gift cards awarded at the close of the study.

**Risks:** There are no risks associated with this study outside of risks associated with normal daily life activities.

**Confidentiality:** All student responses and correspondence will be identified only through a 4-digit pin chosen by the student and unknown by the researcher or instructor for the course. Physical data sources, such as consent forms will be destroyed after the conclusion of the study. Before conclusion of the study, physical data sources will be kept in a locked file cabinet or password-locked digital files by a research associate. For the analysis and reporting of findings, pseudonyms will be used in order to protect the identities of the participants.

**Alternative Procedures:** There are no alternative procedures for this study.

**Participant’s Assurance:** Whereas no assurance can be made concerning results that may be obtained (since results from investigational studies cannot be predicted) the researcher will take every precaution consistent with the best scientific practice. Participation in this project is completely voluntary, and participants may withdraw from this study at any time without penalty or prejudice. Questions concerning the research should be directed to Erin Riggins at 228-897-3745. This project and this consent form have been reviewed by the Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research participant should be directed to the Chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5116, Hattiesburg, MS 39406-0001, (601) 266-5997. A copy of this form will be given to the participant.

**VERY IMPORTANT:**

**Signatures:** In conformance with the federal guidelines, the signature of the participant must appear on all written consent documents. The University also requires that the date and the signature of the person explaining the study to the subject appear on the consent form.

☐ I, the consenting participant, am at least 18 years of age. Remember, your data is anonymous to the researcher and instructor, and there are no requirements for the study other than course assignments already required for course credit.

☐ I DO NOT consent to the use of my data in the final analysis for this research project.
4-DIGIT PIN – PLEASE CHOOSE A NUMBER YOU WILL REMEMBER BECAUSE THIS IS WHAT YOU WILL USE TO SIGN INTO EACH SURVEY, PRETEST, OR POSTTEST.

COURSE SECTION (PLEASE INCLUDE COURSE SECTION, INSTRUCTOR NAME, AND WHETHER ONLINE OR ONSITE – THE SECTION SHOULD BE ABLE TO BE FOUND IN CANVAS.)

M. Erin Riggins 6/2/14

Signature of the Person Explaining the Study Date

****To submit this form, sign and scan it and email to ______________ or take a picture of it and email to the same email address. If you forget your 4-digit pin, please also email her to retrieve the pin. IT IS SO VERY IMPORTANT TO USE THE SAME PIN FOR EACH ACTIVITY!

THANK YOU TRULY FOR YOUR PARTICIPATION!!
Course Number and Name: BIO 1134 General Biology I
Department/Program: Science Department/ Biology
Semester Credit Hours: 4

Contact Hours per Week:
Lecture: 3
Laboratory: 2

Prerequisite Courses: None

Course Description:
A combined lecture and laboratory course for science majors that includes study of the scientific method, chemistry relevant to biological systems, cell structure and function, cell processes including photosynthesis and cellular respiration, cell division, genetics, and molecular genetics.

Labs associated with this course contain experiments and exercises that reinforce the principles introduced in lecture classes.
Mississippi Gulf Coast Community College is an Equal Opportunity Employer and welcomes students and employees without regard to race, color, religion, national origin, sex, age, or qualified disability.

**COURSE-LEVEL STUDENT LEARNING OUTCOMES**

Upon the successful completion of this course, the student will be able to:

<table>
<thead>
<tr>
<th>Task Description</th>
<th>Estimated Direct Instruction Time</th>
<th>Estimated Out-of-Class Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define and apply the Scientific Method.</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Demonstrate an understanding of basic chemistry of relevance to biological study.</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Describe cell structure and physiology.</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Describe and relate cellular processes.</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Compare and contrast the different types of cell division.</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Describe Genetics and compare and analyze cellular molecular genetics.</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>60</strong></td>
<td><strong>120</strong></td>
</tr>
</tbody>
</table>

**REFERENCES/TXTBOOKS:**


CONTENT OUTLINE

LECTURE

1. Intro. To the Science of Biology/ Scientific Method
2. Basic Chemistry
3. Chemistry of Life, Organic Molecules
4. The Cellular Basis of Life and Cell membranes
5. Cell Division Mitosis & Meiosis
6. Cellular Processes

LABORATORY

1. Scientific Method
2. Metrics
3. Chemical Components of Cells
4. Animal & Plant Cells
5. The Microscope
6. Cellular Processes
7. Mitosis & Meiosis
8. Human Inheritance
9. DNA modeling

EVALUATION AND ASSESSMENT METHODS:

Final Averages are based on a combination of homework, quizzes, program assignments, lab activities, projects, reports, lecture tests and lab texts. The following 10-point scale is used:

<table>
<thead>
<tr>
<th>Grading Scale</th>
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</thead>
<tbody>
<tr>
<td>A = 90-100</td>
</tr>
<tr>
<td>B = 80-89</td>
</tr>
<tr>
<td>C = 70-79</td>
</tr>
<tr>
<td>D = 60-69</td>
</tr>
<tr>
<td>F = 59 and below</td>
</tr>
</tbody>
</table>

REASONABLE ACCOMMODATION:

If you have a disability of any kind and will need reasonable accommodations or assistance in the classroom or with this course, please see the instructor the first day of attendance.
APPENDIX N

EXAMPLE OF ONLINE CLASS VIRTUAL LAB

Practice Focusing the Microscope Dropbox

You will go to the website and practice focusing a microscope. This is the closest that you will be able to get to using a real microscope in an online class.

1. Follow the tutorial offered when you enter the website.
2. You will view each slide (letter e, bacterial capsule, cheek cell, onion root tip).
3. You will practice focusing and locate the red circled object in 10 times and 40 times magnification.
4. I want you to take a screen shot of the red circled object in 40 times magnification. Just press the Print Scr button on the keyboard. Then, open a blank Word File and just press Paste. Print Scr button functions just like Copy.
5. Once you have a screen shot of each slide under 40x magnification, you will upload this file into the dropbox.

http://www.udel.edu/biology/ketchammicroscope/scope.html

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APPENDIX O

EXAMPLES OF ONLINE CLASS SHOW ME (WHITEBOARD LECTURES)
APPENDIX P

EXAMPLE OF ONLINE CLASS STUDY GROUP DISCUSSION BOARD ASSIGNMENT

Since this is a group discussion, each group has its own conversation for this topic. Here are the ones you have access to:

- Project Group 2
- Project Group 3
- Project Group 4
- Project Group 1

Group Discussion Ch 1, 2, 3, and Metrics

For this discussion, you are split into groups. Each group will be able to pose questions or topics from the chapters on the upcoming test (Ch 1, 2, 3, and metrics) that they would like to have more help with. What I want you to do is post something first, but then read through the other posts afterwards to see if you are able to help. You will need to comment at least twice, if not more. Your comment can be an answer, an explanation, a link to a website that you found useful, etc. You are actually getting a grade for this study session, so make it worth it!
REFERENCES


Burgess, J. V. (2006). Transactional distance theory and student satisfaction with web-


Huang, H. (2002). Toward constructivism for adult learners in online learning


and online: Scientific explorations through distance learning. *Open Learning, 26*, 135-146.


Wilson, K., & Fowler, J. (2005). Assessing the impact of learning environments on