12-3-2012 12:00 AM

Transactional Distances In An Online Histology Laboratory Course

Michele L. Barbeau, *The University of Western Ontario*

Supervisor: Dr. Kem A. Rogers, *The University of Western Ontario*

A thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree in Anatomy and Cell Biology

TRANSACTIONAL DISTANCES IN AN ONLINE HISTOLOGY LABORATORY COURSE

(Spine title: Transactional Distances in an Online Histology Course)

(Thesis format: Integrated Article)

by

Michele L. Barbeau

Graduate Program in Anatomy and Cell Biology

A thesis submitted in partial fulfillment
of the requirements for the degree of
Doctorate of Philosophy

The School of Graduate and Postdoctoral Studies
The University of Western Ontario
London, Ontario, Canada

THE UNIVERSITY OF WESTERN ONTARIO
School of Graduate and Postdoctoral Studies

CERTIFICATE OF EXAMINATION

Supervisor	Examiners
Dr. Kem A. Rogers	Dr. Peter Merrifield
Supervisory Committee	Dr. Brian Allman
Dr. Marjorie Johnson	Dr. Brad Urquhart
Dr. Candace Gibson	
Mr. Kim Holland	Dr. Wojciech Pawlina

The thesis by

Michele Louise Barbeau

entitled:

Transactional Distances in an Online Histology Laboratory Course

is accepted in partial fulfillment of the
requirements for the degree of
Doctorate of Philosophy

Date

Chair of the Thesis Examination Board

Abstract

This dissertation examined the transactional distances that exist in an online histology laboratory course assessed through student interactions with the course content, instructors and fellow students. The interactions in the online course were compared to those in a face to face (F2F) course covering the same content.

The student-content interactions were assessed through student course outcomes and lecture attendance. Results showed there were no differences in student performance on assessments between the course formats; however, overall student attendance levels were significantly greater in the online course. These results suggest that online students spent more time interacting with course content. It was also shown that there was a direct relationship between lecture attendance and course performance for both online and F2F students. With higher overall attendance rates and a correlation between lecture attendance and course performance, it would be expected that online students would have higher course outcomes compared to the F2F students. The fact that there were no differences in student outcomes suggests that some transactional distance still exists between online students and course content.

Student-instructor interactions were examined through an assessment of student questions during the laboratory sessions. Results indicated that the transactional distance between the online students and instructor was lower than that with the F2F students with online students asking questions at higher rates. However, while technology allowed students to communicate synchronously with the instructor, online attendance patterns showed that students preferred to view archive recordings of the lectures, thus maintaining some transactional distance in the online course.

The incorporation of synchronous peer teaching to the laboratories was an attempt to increase student-student interactions. Improved laboratory outcomes for both online and F2F students were shown; however, the impact was greater with the online students possibly due to the fact that F2F students were already engaging in informal peer teaching. Due to low survey response rates, it was not possible to show differences in the student's perceived impact of peer teaching on group dynamics.

While technology has improved the transactional distances in online courses, some transactional distances are maintained, often by student choice which is also enabled through technology.

Keywords

Online Education, Transactional Distance, Student Interactions, Histology, Laboratory Course, Post Secondary Education, Attendance, Peer Teaching, Student Outcomes

Co-Authorship Statement

The written material in this thesis is the original work of the author. Michele Barbeau participated in all aspects of the work contained within this thesis including: conception of the hypothesis, conduct of the research, and preparation of the manuscripts. The roles of co-authors are detailed below.

Chapter 3: Design and Evaluation of Online Histology Course

Funding for the creation of the virtual microscope was provided by Drs. Marjorie Johnson and Candace Gibson. The slides were scanned by Michael Mitchell and the website displaying these scanned slides was created by Stuart Thompson and David Arromba. The course was designed by Michele Barbeau and Dr. Kem Rogers. The concept of comparing the online and face to face courses was from Dr. Kem Rogers. The data was collected, analyzed and interpreted by Michele Barbeau. The preparation of the manuscript was performed by Michele Barbeau with input from Drs. Kem Rogers, Marjorie Johnson and Candace Gibson. This manuscript has been accepted for publication in Anatomical Sciences Education (ASE-12-0088).

Chapter 4: Student Attendance

The concept of this research was created by Michele Barbeau. The data was collected, analyzed and interpreted by Michele Barbeau. Michele Barbeau created the Exam Question Index Score with input from Dr. Kem Rogers. The preparation of the manuscript was performed by Michele Barbeau with input from Dr. Kem Rogers. This manuscript will be submitted to Computers and Education.

Chapter 5: Student Engagement

The concept of this research was created by Michele Barbeau. Laboratory question data was collected by the laboratory teaching assistants: Zachary Armstrong, Stefanie Attardi, Bethany Bass, Mark Ableser, Ryan Rawski and James Turgeon. Zachary Armstrong and Stefanie Attardi assisted with the creation of the peer teaching groups. The data was collected (with noted exception), analyzed and interpreted by Michele Barbeau. The preparation of the manuscript was performed by Michele Barbeau with input from Dr. Kem Rogers. This manuscript will be submitted to Anatomical Sciences Education.

Acknowledgments

The completion of this work would not have been possible without the support and encouragement from the people who surround me.

First, I would like to thank Dr. Kem Rogers who was my supervisor for this project. It was his love of new things which was the seed that started this project. His patience, support and encouragement over the years of this project and all the years I have known him have left me with a "can-do" attitude I hope to never lose.

I would also like to extend my sincere gratitude to Dr. Marjorie Johnson who encouraged me to enroll in this program and also served as a valuable advisor and mentor throughout. I also appreciate the guidance and advice I received from my other advisory committee members Dr. Candace Gibson and Mr. Kim Holland. I would also like to thank Dr. Chris Lee for his assistance with the data analysis for this project. I would like to thank the members of the Department of Anatomy and Cell Biology who have been supportive and encouraging. Specifically, Zachary Armstrong who patiently endured many of my talks in their early stages.

I consider myself fortunate to have been taught by Drs. Francis Chan, Peter Haase, Timothy Wilson and Marjorie Johnson, all exceptional creative teachers who have inspired me. I aspire to be as engaging and inspirational as all of you!

I would also like to thank my husband, Ted Tweedie and my children John, Douglas and Tommy for their support and understanding throughout this degree. As well, my parents, Jon and Marion Barbeau have been very helpful and wonderful cheerleaders for me over my entire academic career.

Finally, I would like to thank my office mates Ngan Nguyen and Charys Martin who have been there since the beginning and Victoria Roach and Stefanie Attardi who joined them later. They are all exceptionally bright, energetic women who have been an enormous source of help, inspiration and fun for me during this degree. It would not have been the same without you!

Table of Contents

List of Tables

List of Figures

List of Appendices

Chapter 1

1 General Introduction

1.1 Distance Education

Formal distance education began with students who were seeking autonomy and flexibility in their learning but still wanted some guidance from an instructor (Wedemeyer, 1971). In these initial correspondence courses, student and teacher were physically separated and usually communicated by mail. This type of communication was relatively slow and thus student and teacher were not only physically separated but also separated by long periods of time. Despite these separations, such courses gave students who might not normally be able to participate in regular educational programs, the opportunity to learn. These students might include those who are geographically isolated or in poor health. Today, these correspondence courses have evolved into several forms. One of the most prominent at post secondary institutions is the online distance education course. This type of correspondence course still has the physical separation of student and teacher but uses the internet and email to decrease the temporal separation. Many online distance education courses are offered synchronously, where student and instructor can communicate in real time so that there is no temporal separation.

Post secondary institutions are increasing the number and type of online courses they are offering. As well, more students are registering for these courses with approximately 25% of the student population expected to take at least one online course during their post secondary education (Allen and Seaman, 2010). Despite the increase in the number and types of courses being offered, the number of options for science students is not increasing at the same rate. A meta-analysis examining 125 online courses included only 16 which were post secondary science or mathematics courses (Shachar and Neumann, 2010). Analysis of these courses focused on outcome measures to ensure the course was of high quality and at least as effective as a traditional face to face (F2F) course covering the same content. Although there are some online options for science students, more work is needed to develop more courses and then analyze them for ways to optimize their effectiveness.

1.2 Transactional Distance

Learning in the distance education classroom has many factors in common with traditional classroom teaching, however, there are some features which are unique and based on the psychological and communicative separation of the learner from the other facets of the course (Moore, 1993, 2007). The transactional distance is the interplay of the learner with their environment (Moore, 2007). This interplay exists in all educational environments, but due to the unique conditions of the distance education classroom environment based on physical and temporal separation, the transactional distance becomes important with respect to student success (Moore, 2007). The transactional distance is a theoretical continuous variable where the level of distance is directly associated with the level of student autonomy (Moore, 2007).

Moore classified the interactions in the transactional distance as the interactions between the student and different facets of the classroom (Moore, 1989). These three types of interactions include: 1) student–content, 2) student–instructor and 3) student–student. The student–content interaction refers to the process of the student learning the course content. It includes the integration of new knowledge into the learner’s existing knowledge schema resulting in a change in the learner. The student–instructor interaction is considered the most important of these interactions and refers to the methods the instructor uses to facilitate the student–content interaction as well as feedback from the instructor to motivate the student. The third type of interaction is that of student–student. This peer interaction is also an important contributor to the process of learning.

A fourth type of interaction has been introduced by Hillman, Willis and Gunawardena (1994) which is that of the student–interface interaction. This interaction is especially important as increasingly complex technology is often employed in current distance education courses. Often, a technology skill set is required to access and interact with the course content, instructor and other students. It is the combination of these interactions which results in “deep and meaningful formal learning” (Anderson, 2003) where at least one of the interactions described by Moore (1989) must be at a high level. When high levels of more than one of these interactions occur, an enriched learning experience will be provided (Anderson, 2003).

1.3 Histology

Microscopic anatomy or histology has traditionally been an important component of medical education (Barr, 1977). This role was expanded to include those who are currently undergraduate bachelor of medical science students as its importance was also recognized for these students as well (University of Western Ontario, 1965). Typically, histology courses include a laboratory component where students follow a laboratory guide and use individual microscopes and glass slide collections to view the structures. In recent years, the incorporation of virtual microscopy, where the glass slide collections have been digitized and made available to students through the internet, has led to changes in the histology teaching laboratory where microscope use has been reduced or replaced with virtual microscopy (Drake et al., 2009). Many courses now use virtual microscopy either exclusively or in combination with traditional microscopy in the teaching laboratory. Although students using virtual microscopy do not gain the physical microscopy skills used to manipulate the instrument in order to evaluate a whole slide and find specific cell types or structures (Cotter, 2001), there are many benefits to using virtual microscopy in the teaching laboratory that outweigh this negative aspect (Harris et al., 2001; Pratt, 2009). These benefits include increased opportunity for collaboration, standardized slide collections, easily prepared teaching materials and an opportunity for study outside of laboratory hours. An additional benefit to virtual microscopy is that it lends itself to the incorporation into an online distance education course due to the fact that only a computer and internet connection are required (Sinn et al., 2008).

1.4 Overview of Dissertation

The purpose of this dissertation is to examine the theory of transactional distance through an online distance education histology laboratory course. Have millennial students and advances in technology changed the transactional distances Moore described in the 1980's version of the distance education classroom? Do these transactional distances still impact the distance education classroom?

Chapter 2 of this dissertation will provide background information on distance education and the histology curriculum. An examination of the evolution of histology into its current state, including a review of studies examining the use of virtual microscopy in histology education has been detailed. This is followed by a definition of learning and a description of learning theories and styles. The forms of distance education have been described and studies evaluating the effectiveness of online education have been reviewed. Factors influencing student success were also examined in a review of studies of the impact of previous grades and attendance on student performance in both F2F and online courses. Finally, student engagement was examined through the interactions between students and instructors in the form of questions and student interactions with their peers.

A description of the development of an online histology laboratory course has been provided in Chapter 3. The interactions in the theory of transactional distance have been assessed in this course through a comparison with the same course offered in a F2F format. Student-content interactions have been assessed through student outcomes (Chapter 3) and student attendance (Chapter 4). In addition, correlations between attendance and outcomes have been explored. Student-instructor interactions have been examined through an analysis of student questions during the laboratory periods (Chapter

5). A peer teaching exercise, incorporated into the laboratories, examined the impact of student-student interactions during the laboratory sessions (Chapter 5).

Finally, Chapter 6 is a general discussion and conclusion for Chapters 3–5. Here the transactional distances have been examined based on findings from these studies and conclusions drawn about the current state of transactional distances in the distance education classroom in 2012. Lastly, suggestions for future studies on the online distance education classroom will be provided.

1.5 Literature Cited

Allen IE, Seaman J. 2010. Learning on Demand: Online Education in the United States, 2009. In, 1st Ed. ed. Newburyport, MA: Babson Survey Research Group, Sloan Consortium, Inc. p 29.

Anderson T. 2003. Getting the mix right again: An updated and theoretical rationale for interaction. In: Int Rev Res Open Dist Learn.

Barr M. 1977. A Century of Medicine at Western. London, Ontario: The University of Western Ontario.

Cotter JR. 2001. Laboratory instruction in histology at the University at Buffalo: Recent replacement of microscope exercises with computer applications. Anat Rec 265:212-221.

Drake RL, McBride JM, Lachman N, Pawlina W. 2009. Medical education in the anatomical sciences: the winds of change continue to blow. Anat Sci Educ 2:253-259.

Harris T, Leaven T, Heidger P, Kreiter C, Duncan J, Dick F. 2001. Comparison of a virtual microscope laboratory to a regular microscope laboratory for teaching histology. Anat Rec 265:10-14.

Hillman DCA, Willis DJ, Gunawardena CN. 1994. Learner - interface interaction in distance education: An extension of contemporary models and strategies for practitioners. Am J Dist Educ 8:30-42.

Moore M. 1989. Editorial: Three types of interaction. Am J Dist Educ 3:1-7.

Moore M. 1993. Theory of transactional distance. In: Keegan D, editor. Theoretical Principles of Distance Education: Routledge p22-38.

Moore M. 2007. The Theory of Transactional Distance. In: Moore M, editor. Handbook of Distance Education, 2nd ed. Mahwah, NJ: Lawrence Erlbaum Associates Inc. p 89-105.

Pratt RL. 2009. Are we throwing histology out with the microscope? A look at histology from the physician's perspective. Anat Sci Educ 2:205-209.

Shachar M, Neumann Y. 2010. Twenty years of research on the academic performance differences between traditional and distance learning: Summative meta-analysis and trend examination. MERLOT J Online Learn Teach 6:318 - 334.

Sinn HP, Andrulis M, Mogler C, Schirmacher P. 2008. Virtual microscopy in pathology teaching and postgraduate training (continuing education). Pathologe 29:S255-S258.

University of Western Ontario. 1965. Arts and Science Calendar 1965-66. London, Ontario.

Wedemeyer C. 1971. Independent Study. In: Deighton R, editor. Encyclopedia of Education: MacMillan. p 548-557.

Chapter 2

2 Literature Review

2.1 Histology Education

2.1.1 Histology in the Medical Curriculum

At the founding of the Medical School at Western University in 1882, microscopic anatomy or histology formed a core component of the basic sciences in the medical school curriculum. Histology, the study of the microscopic anatomy in normal tissues, has historically provided medical students with an introduction to normal and pathological tissues, which is integral to their understanding of disease processes. These students were supplied with microscopes and were required to prepare their own personal slide set from which to study (Western University, 1886). The practice of preparing personal slide sets continued into the 1940's after which students were supplied with prepared slide sets (Barr, 1977). The course remained an important component of the curriculum with between 144 and 192 hours devoted to the subject. During the 1960's histology instruction was aligned to correspond with the progress of dissection in gross anatomy (University of Western Ontario, 1961).

The histology course was maintained as a separate 70 hour course until 1997, at which time it was integrated with gross anatomy and coordinated with other subjects being offered concurrently in the medical curriculum (University of Western Ontario, 1997). With this change, there were no longer formal laboratory sessions for the students as time demands from other subject areas increased. Currently, histology instruction for medical students is integrated with anatomy and embryology to form a comprehensive anatomy course. There are 120 hours devoted to anatomy which includes both laboratory and lecture hours. For the histology component, students are supplied with images of micrographs and they also have access to Western University's online virtual microscope. All but 11 hours of the traditional histology lectures have been incorporated into pathology or physiology modules. The histology component of the medical curriculum has evolved from a labour intensive course to one where there are few lectures and self directed computer learning modules.

2.1.2 Undergraduate Histology

As part of the honours science program and later the Bachelor of Medical Sciences, undergraduate students could take histology in their third or fourth year. The course was and continues to be a comprehensive laboratory course in human and mammalian histology. It complements the other courses in the program such as physiology, gross anatomy, pathology and genetics. The undergraduate course has also undergone a transformation from a comprehensive course of approximately 40 to 60 students, to a large class of over 150 students, an online course with over 75 students and a summer online version of the course with more than 60 students. The laboratory component of the course has evolved from the exclusive use of microscopes and glass slide collections to the combination of microscopes and virtual microscopy, using digitized slide collections for the face to face (F2F) course and the exclusive use of a virtual microscope for the online course. This transformation is in keeping with what other institutions are currently using to teach histology (Drake et al., 2009).

Laboratory exercises allow students the opportunity to discover the course material in a "hands-on" way. A typical histology laboratory would begin with a pre-laboratory talk, using glass or virtual slides to show relevant structures live, a technique that has been shown to enhance learning (Higazi, 2011). Students then turn to their own slide collections to find these structures and complete assignments. Histology textbooks and atlases traditionally present exemplars of structures that students are required to locate; but exemplars rarely appear in the eyepiece of a microscope. The students are then forced to use their knowledge to relate the specific structural example before them to the image from the text. This is a valuable learning experience. In the histology laboratory, students are usually asked to examine slides using the microscope and find different cells or tissues. Students learn how to "read" the slide (Cotter, 2001). Often these slides may contain imperfections or artifacts such as folds, debris or poorly stained areas. Through the laboratory exercises, the students learn how to evaluate the slides and find examples of the structures they are looking for (Bloodgood and Ogilvie, 2006). This evaluation process would be lost if they were only presented with textbook images of the structures being studied. Virtual microscopy retains this valuable learning experience and is ideally suited to the online education environment because it requires only a computer and internet connection for functionality (Sinn et al., 2008; Helle and Säljö, 2012).

2.1.3 Virtual Microscopy

Traditionally, histology courses have included viewing glass specimen slides as a component of laboratory exercises. However, innovations in technology have allowed for glass slides to be scanned and converted to digital images and viewed on computers with the same visual manipulation as traditional microscopes; effectively replacing the need for microscopes in the laboratory (Lundin et al., 2009; Helle et al., 2011). A virtual slidebox can be created using virtual microscopy software where glass microscope slides are scanned at high (40x) magnification followed by placing the resulting computer files online for students to view at their convenience. The virtual microscope software allows the computer to mimic the actions of a microscope by allowing the user to navigate around the slide and change magnifications. Cotter (2001) has described the process in which slides are typically viewed to detect key structures as "reading" the slide where a student is able to examine the whole slide and find and identify different structures on a specimen. This ability to "read" the slide is considered valuable to the student as it helps them identify and understand the structures studied.

Attempts have been made to introduce computer aided instruction into the histology classroom using still images placed within a computer learning module (Mars and McLean, 1996; Cotter, 2001); however, the use of still images on the computer is equivalent to an online atlas. The student would not have the opportunity to interact with the slide to "read" it. The use of virtual microscopy, where the whole slide is digitized allows for this type of interaction (Lundin et al., 2004b). Virtual microscopy was initially introduced to the histology classroom in 2001 (Harris et al., 2001) and since its introduction, has been tested for its potential uses and effectiveness.

A recent survey by the American Association of Anatomists indicated that the majority of institutions offering histology courses now use virtual microscopy, either exclusively or in combination with traditional microscopy, confirming that this technology has become commonplace in the histology teaching laboratory (Bloodgood and Ogilvie, 2006; Drake et al., 2009).

There have been many attempts to validate virtual microscopy as an educational tool in comparison to traditional microscopy (Harris et al., 2001; Krippendorf and Lough, 2005; Goldberg and Dintzis, 2007; Scoville and Buskirk, 2007; Braun and Kearns, 2008; Pinder et al., 2008; Husmann et al., 2009). These studies have found student outcomes to be either equivalent to (Scoville and Buskirk, 2007; Braun and Kearns, 2008; Pinder et al., 2008) or better than (Goldberg and Dintzis, 2007; Husmann et al., 2009) those where traditional microscopy was used. Scoville and Buskirk (2007) conducted a cross-over study to ascertain the impact of teaching and evaluation using both traditional and virtual microscopy paradigms. They found that there were no significant differences between learning or evaluations using virtual and traditional microscopic modalities. Studies have also highlighted the unique uses of the virtual microscope. Several studies have shown that virtual microscopy provides a more efficient method of learning over traditional methods when considering logs of student study hours and overall performance (Krippendorf and Lough, 2005; Braun and Kearns, 2008). In addition to student academic outcomes, these studies also included survey responses from students. Many students preferred using the virtual microscope, for reasons including ease, accessibility and the ability to collaborate more readily. A survey of instructors has echoed students' comments with the added caution that, with the availability of the virtual microscope outside of class time, students may not be using class time optimally (Collier et al., 2012).

Virtual microscopy has been shown to be beneficial in a medical school taught with satellite campuses (Pinder et al., 2008). This technology has allowed a large number of students access to the same high quality slide sets despite being in different physical locations providing uniformity in the course.

A study using undergraduate students instead of medical students has also shown a significant increase in student laboratory grades compared to the previous year using traditional microcopy (Husmann et al., 2009). Reports have suggested that student collaboration is easily facilitated using virtual microscopy (Goldberg and Dintzis, 2007; Pinder et al., 2008; Bloodgood, 2012; Collier et al., 2012; Shaw and Friedman, 2012) including one study which also demonstrated improved examinations scores through collaboration (Goldberg and Dintzis, 2007). Bloodgood (2012) has described an effective group active learning and peer teaching exercise utilizing the collaborative aspects of virtual microscopy where students formed small groups and presented virtual slides to their peers. Although no improvement in grades was demonstrated, the exercise was well received by the students based on feedback.

Instructors can also benefit from using virtual microscopy. Reports have described its use in the preparation of examinations for medical students (Blake et al., 2003), accreditation exams for post graduate medicine (Hassell et al., 2011) and for the preparation of specialized teaching materials (Lundin et al., 2004a). Critics of virtual microscopy lament the loss of microcopy skills gained by students (Coleman, 2009), a concern shared by students themselves (Pinder et al., 2008). A survey of physicians showed that 66% of respondents used histology knowledge daily or weekly and that 90% believed microscopy skills and a general knowledge of microscopy were important (Pratt, 2009). The use of the virtual microscope itself is becoming a necessary skill as its use increases in clinical and continuing educational settings as well as competency evaluations (Lundin et al., 2004a; Coleman, 2009; Dee, 2009; Lundin et al., 2009; Pratt, 2009; Shaw and Friedman, 2012). It is also important to remember that microscopy skills are widely used by many other individuals in the medical sciences, such as researchers and technicians. Therefore, the effect of the absence of this learned skill may be undervalued in the literature as the main focus of publications is on medical students and physicians.

For the institution, there are significant advantages to adopting digital microscopy, inclusive of maintaining the availability of high quality slides (specimens) for all of its students and ultimately saving on costs associated with slide and microscope maintenance. Despite initial start-up costs and time required to digitize the slides, these costs are recouped through decreased maintenance costs.

In summary, virtual microscopy has become widely accepted as either a substitute or a supplement to traditional microscopy in the histology classroom (Drake et al., 2009). It also allows for more effective collaboration and easier preparation of teaching materials. The ability to access the slides at anytime and anywhere makes this method of studying histology ideally suited to a distance education classroom setting (Helle and Säljö, 2012)

2.2 What is Learning?

2.2.1 Learning Defined

Any study involving student learning needs to begin with a working definition of what learning actually is.

> "Learning is a change in knowledge attributable to experience" (Mayer, 2011)

This definition consists of several important elements. First, there is a change which occurs in the learner. This change is long lasting. Second, the change is in the knowledge of the learner. Knowledge can be knowledge of facts, procedures, concepts, strategies or beliefs. Knowledge cannot be directly measured but it is inferred through the behavior of the learner. For example, knowledge of facts can be demonstrated by correctly answering questions based on those facts on a test. The knowledge has not been directly measured but has been demonstrated using the test.

The third essential element of the definition is that learning is caused by the learner's experience. It is the learner's interaction with their environment which will cause the change in their knowledge. Instructors are faced with the task of creating an environment which will facilitate learning. Environmental factors which have been shown to influence learning include the amount of practice the learner has with the new information or skills and the time between learning and testing. More practice results in greater knowledge acquisition and greater amount of time between learning and testing results in less knowledge retained. Although learning is long lasting, forgetting does occur if new the knowledge is not used, however, relearning occurs more quickly on subsequent attempts to learn the material.

2.2.2 Learning Theories

There are two main theories of how learning occurs: behaviorist view and cognitive view. The behaviorist view defines learning as a change in behavior because behavior is what is directly observable. This is the earlier view of learning which was reinforced by experiments using response learning and animal models. For example, a rat could be trained to push a certain lever and receive a food reward. Some levers would produce no reward and only one would lead to a food reward. The rat will quickly learn which lever produces the reward and will demonstrate this leaning through its behavior. The behaviorist view of learning was supported by these simple animal models until human learning was more widely studied when this view could no longer adequately explain the complex learning which occurred in humans. In contrast, the cognitive view of learning attempts to explain the more complex learning observed in humans. In this view, there is a change in the learner's knowledge and this knowledge is inferred through a change in the learner's behavior. The difference between the behaviorist and cognitive views is that the cognitive view incorporates the mental processes involved in the observable behaviors.

A third theory which builds upon the cognitive theory is constructivism. Based on the work of Vygotsky who theorized that individuals learn only when they are socially, culturally and biologically ready to learn (Bruner, 1986; Lutz and Huitt, 2004). Constructivism is similar to the cognitive theory where the learner's mental processing of the knowledge is considered; however, constructivism also includes consideration of a student's prior knowledge and how that prior knowledge provides a framework for the learner to incorporate new knowledge (Cooperman, 2007). The constructivist theory is currently the most popular educational theory (Lutz and Huitt, 2004).

These theories are useful for instructors to help them guide their instructional and assessment activities. For example, a behaviorist approach to learning would involve designing the course such that learner outcomes are divided into goals to be mastered. The instructor would then create the appropriate environment to present these goals and then later determine if these goals have been met. This is knowledge acquisition which is assessed by the behavior. The cognitive theory approach to course design would also involve course goals or skills to be mastered; however, there would be the additional need for the instructor's attention to help develop teaching strategies which will enable the learner to organize the new information (Cooperman, 2007). Therefore, while these theories may not seem to have practical relevance, a well designed course will use these theories as the framework on which the content is applied.

2.2.3 Cognitive Versus Learning Style

In the design of courses, both cognitive and learning styles of the student have been studied to ensure that the delivery of the material is beneficial to all learners. Cognitive style refers to individual traits such as perception, memory and judgment, or how an individual thinks about the information. These are stable traits of the individual which are impacted very little by teaching styles. In reference to the learning theories, cognitive style would impact how the learner incorporates prior knowledge and experience to the new information. In contrast, learning styles are the strategies the learner uses to approach learning tasks. These are conscious and intentional and are impacted by teaching styles (Curry, 2002). Numerous attempts to classify learning styles have resulted in categories where learners fall on a spectrum between visual and verbal preference for learning (Felder and Silverman, 1988) or where learners are for example, kinesthetic, visual or multi-modal learners (Fleming and Mills, 1992). The practical importance of these learning styles is that instructors should be aware that there are students with a variety of learning styles and opportunities should be incorporated into the teaching methods and materials for students to learn the course content using more than one learning style. For example, visual learners may prefer to learn from pictures and graphical representations, aural learners prefer to hear the information and kinesthetic learners may prefer to discover the information through active learning. The instructor should structure courses to allow the information to be presented in several formats.

2.2.4 Summary and Practical Application

An understanding of how individuals learn based on learning theory provides an instructor with a framework with which to guide the student. Using constructivist theory, the instructor can introduce the course material in increasing complexity as the students build their knowledge base in the subject area. An understanding of different learning styles helps the instructor understand how the presentation of the course material will impact different students. Faced with a class of students with varied learning styles, the instructor should be incorporating different learning methods into the course design. For example, in the histology course described in this dissertation (Section 3.2.2), there was extensive use of images, both actual and schematic, incorporated into the lectures facilitating the visual learner. Laboratory activities requiring hands on manipulation of the microscope facilitate the kinesthetic learner. The course begins with basic cell structures then progresses to how these cells work together to form tissues and ends with how different tissues work together to form the various organ systems. As students progress through the course, it is assumed that the previous topic has been incorporated into their knowledge base so that the new topic can build on that knowledge. Thus the progression of the course content is based on constructivist principles.

2.3 Post Secondary Education

2.3.1 Post Secondary Education Trends

In the United States, enrolment in postsecondary institutions has increased by 38 per cent in the last decade, hitting record levels. This trend is expected to continue for a number of years. The increase in enrolment is not only due to an increase in the general population, but the number of people choosing to enter post secondary institutions (Snyder and Dillow, 2011). At Western University we have also seen record levels of enrolment (Travis, 2011). Economic downturns, such as what was experienced in 2008, have traditionally been followed by increases in post secondary enrolments (Usher and Dunn, 2009). Unfortunately, economic downturns also bring decreases in public funding for these institutions. The combination of more students and less funding presents a difficult situation for post secondary institutions: How can quality education be offered to more students with less funding available to do so? One solution to this problem has been to increase class size. For science courses, which benefit from the addition of hands on laboratory exercises, there is a limit to the number of students which can be physically accommodated. One innovative solution to the problem of over-crowding is to offer distance education courses which would not be limited by physical classroom size.

2.3.2 Millennial Students

Strauss and Howe (1991) coined the term "millennial generation" for individuals born between 1982 and 2003 (Howe and Strauss, 2003). The beginning of this generation was marked with a change in social attitude toward the greater protection of children which has had an impact on their behavior (Strauss and Howe, 1991). Other societal events such as the terrorist attack of September 11, 2001 and the economic downturn beginning in 2008 helped shape the characteristics of this generation, similar to the ways events in society influenced other generations as they progressed through the stages of life (Strauss and Howe, 1991; McBride and Nief, 2011). This generation currently makes up the majority of the post secondary student population. Reported characteristics of these students have typically described them as being special, sheltered, confident, team-oriented, high achieving and pressured (Howe and Strauss, 2003), while the learning styles of this generation have been reported as students who preferred active learning, working in small groups, and preferred learning using technology (DiLullo et al., 2011). On the negative side, this generation has been described as narcissistic, dependent, deficient in time management, and critical thinking skills (DiLullo et al., 2011). Although these reports are generalizations and do not apply to all students from this generation, these traits are considered with respect to changes in academia. Millennial students have grown up with access to the internet and are generally comfortable using technology (McBride and Nief, 2011). The embracing of technology by these students has encouraged the incorporation of technology into the teaching methods (Mangold, 2007; DiLullo et al., 2011). Part of this transformation has included a significant increase in the popularity of online distance education (Allen and Seaman, 2010). The technology-loving millennial student in combination with current economic pressures are some of the reasons post secondary institutions are offering more online distance education courses.

2.4 Distance Education

The difference between distance education and the traditional classroom was first identified as “independent study” by Charles Wedemeyer (1971). He described students who did not study in class but used correspondence courses and learned on their own with or without the guidance of a teacher. Distance education has evolved from these correspondence courses where a syllabus and materials were mailed between student and teacher with very little outside support. Today, distance education courses can be online courses with synchronous or real time lectures which provide immediate feedback between students and teacher as well as synchronous interactions between students. Current enrolment in distance education courses is increasing faster than that for post secondary education with 25% of students expected to take at least one distance education course in their education careers (Allen and Seaman, 2010).

2.4.1 Transactional Distance

Interactions between students, instructors and content in undergraduate classrooms play an important role in student success in all formal education (Chickering and Gamson, 1989; Abrami et al., 2011). The three types of interactions occurring in the distance education environment, as described by Moore (1989), are learner-content, learner–learner and learner–instructor.

The learner–content interaction refers to the interaction between the learner and the course content. This interaction allows the learner to integrate new knowledge with their pre-existing knowledge. With learner–instructor interactions, the instructor facilitates learner–content interactions. Instructors behave as they would in any other type of learning environment where they select the information to be included in the curriculum; they deliver the information, motivate the student to learn and provide opportunities which facilitate the incorporation of the new information into student's existing knowledge and then assess the knowledge gains of the learner. In addition, instructors clarify, support and encourage the learner. This interaction is considered the most important by both students and instructors.

The third type of interaction is that of the learner–learner. This type of interaction allows the learners to discuss the content, reveal misconceptions and to teach one another. (Moore, 1989) This type of interaction results in improved learning and motivation for the students (Bernard et al., 2009).

A fourth type of online course interaction has also been described by Hillman et al. (1994). This is the student–interface interaction. This interaction requires that the student understand the tools used to manipulate the online classroom. It has been shown that the use of course technology is related to both the perceived and actual performance of students in a business course (DuFrene et al., 2009). Students must possess the technological skills necessary to access the course content.

Students will obtain the greatest amount of success in a distance education course if at least one of these interactions is considered high quality (Anderson, 2003). If more than one of these interactions is of high quality, then the learning will be enhanced.

While the transactional distances described above are not directly quantifiable or measureable, this theory has been used as a framework to guide research on distance education. Bernard et al. (2009) conducted a meta-analysis on 72 studies looking at different interactions in distance education and the authors organized the studies in terms of Moore's categories (1989). They attempted to answer several questions, including the effects of the various interactions on student achievement, which interaction produces better levels of achievement and which combinations of interactions have the greatest affect on achievement. The results they found were that all three interactions were important for student achievement, but the student–student and student–content were found to be more influential than the student–teacher interaction. They also concluded that improvements in the student–content interaction had the greatest effect in improving student outcomes. This means that when courses were designed with features to help students engage in the content, there was a substantial improvement in student outcomes. The authors therefore stressed the importance of course design to enhance this interaction for online courses. A follow up paper suggested that interactive distance education design should facilitate interactions which are more targeted, intentional and engaging and that research should be focused on validating these interactions (Abrami et al., 2011).

Another study examining the interactions in synchronous distance education classrooms addressed research questions examining graduate student perceptions about the four types of interactions in a distance education classroom and what tools and strategies the instructor can use to enhance these interactions (Martin et al., 2012) Through student surveys they found that most students had positive experiences with the classroom interface (Wimba Virtual Classroom), however, all respondents did indicate that there were occasional malfunctions due to poor Internet connections. The majority of respondents found that the text chat method of communicating with other students created a strong interaction, while there were mixed feelings about the instructor's use of breakout rooms for group work, with four respondents reporting that they did not like break out rooms and two stating that they liked working in groups. Their overall conclusions were that using a synchronous virtual classroom lead to enhanced communication between students and instructor and between fellow students. This communication was also important to the instructor who used it to gauge student understanding of the concepts. To address the initial technical difficulties, they recommended training the students ahead of time and having them conduct the system check and log in prior to class to identify any potential difficulties. Finally, the authors recommended a reference guide for technical difficulties.

Another qualitative study focusing on components of the transactional distance theory was conducted using undergraduate students enrolled in a biology course which included virtual laboratory exercises (Flowers et al., 2012). The majority of survey respondents reported that instructor interaction in the virtual laboratory was reduced compared to the classroom laboratories. Similarly, the majority of respondents reported that the virtual laboratories also decreased their interactions with other students. The authors suggested creating lab groups to address specific questions to increase student–student interactions. Most of the respondents reported that participation in the virtual laboratories increased their understanding of the course material. However, there was no assessment of how the F2F classroom laboratories added to the understanding of the course material. The authors suggest research to identify specific areas where the virtual laboratories could be improved. Finally, with respect to student–interface interactions, the respondents reported a positive impact of their interactions with the educational technology used to deliver and facilitate the laboratory exercises. The authors concluded that there is a "critical" need for research studies which will lead to the development of online teaching strategies aimed at reducing the transactional distance, specifically targeting student–instructor and student–student interactions, thus enhancing student learning in online distance education courses.

The perceptions of distance education faculty gathered through interviews were examined in another qualitative study (Schulte, 2010). Interview questions addressed the various transactions within the distance education classroom and their effects on course content, students and faculty. Common themes were extracted from the interviews. One theme was the difficulty of designing effective group projects and discussions; these would be student-student interactions. Discussion boards were developed to manage this interaction, however one instructor indicated that the "immensity of managing that [discussion board] becomes overwhelming" (Schulte, 2010 p.82). Another described the discussion board interactions of undergraduate students as ineffective and inefficient for learning; however, they did improve with advanced undergraduates and graduate students. Other comments related to instructor–student communication. The main mode of communication was email and the instructors noted that a tremendous amount of time was devoted to the management of email responses often resulting in communication delays because of other responsibilities.

In terms of academic rigor or student–content interactions, the misconception that distance education courses are less rigorous was addressed. The faculty indicated that their expectations and standards for grading for traditional and distance education courses were the same. Assessment of practicum or clinical work was cited as being difficult to assess in an online format. Suggestions were made to create hybrid courses, where a portion of the course is conducted F2F to facilitate practicum or hands on learning. With respect to the student–interface interaction, the instructors were concerned that, because these distance education courses relied on sophisticated technology, there was the possibility that these courses would be inaccessible to some students due to their personal computer limitations. The culminating thoughts of the professors were that distance education was viable with the caveat that "what happens here on campus is hard to replace through distance learning….It's an alternative. It's not a great alternative, but it's an alternative for those that can't be here" (Schulte, 2010 p.95). These comments likely stem from the earlier comments concerning the challenges with interactions both among students and between the student and instructor.

2.4.1.1 Summary of Transactional Distance

Anderson (2003) has developed an equivalency theorem based on the interactions in a distance education classroom. He states that at least one of the interactions (student–student, student–instructor and student–content) be at a high level for meaningful formal learning. However, high levels of more than one of these interactions will likely provide a "more satisfying educational experience" though potentially less cost or time effective. He identifies that the student–content interaction as the most accessible and adaptable. This statement is supported by the preceding studies where both students and faculty reported the least concern in this area. Thus there is a premium on the human based interactions between students and instructors and among students with the student–instructor interaction having the highest perceived value among students. Future research in the area of distance education should focus on enhancing and developing new meaningful interactions between these groups.

2.4.2 Comparison of Online Classes to Traditional Classes

Distance education courses can be either fully online or blended, where a portion of the course is completed online and a portion is F2F. This latter type of course has also been referred to as a hybrid course. Numerous studies have been conducted to compare both blended and fully online courses to traditional F2F courses (Smeaton and Keogh, 1999; Johnson et al., 2000; Grimes, 2002; Bernard et al., 2004; Hale et al., 2009; Means et al., 2009; Dell et al., 2010; Shachar and Neumann, 2010; Jensen, 2011). These studies use student outcomes and/or feedback as comparators. With the rapidly increasing distance education course offerings, it is essential that these courses maintain very high standards. Therefore, the expectation in these studies is that the online courses should be at least as effective as or better than the F2F version.

There have been numerous meta-analyses examining the results of studies comparing online to F2F instruction. Bernard et al. (2004) examined 232 studies published between 1985 and 2002 with the overall conclusions that synchronous applications favoured F2F instruction while asynchronous applications favoured distance education in terms of student outcomes. A closer examination of this study reveals that very few of the studies included were fully online courses; the majority examined the effects of an online application. These would be considered blended or hybrid courses.

Another meta-analysis examined 125 studies published between 1990 and 2009 (Shachar and Neumann, 2010). They also found an overall positive effect of distance education in comparison to traditional education in terms of student outcomes. A closer examination of the studies shows that for those studies published before 2002, only 70% showed an effect favouring distance education in terms of student outcomes. For studies published between 2003 and 2009, those showing a positive effect favouring distance education had risen to 84%. The authors point out that, as instructors gain proficiency with online instruction and students become more accustomed to the online format, the impact of distance education becomes more pronounced.

A third meta-analysis published by the US Department of Education (Means et al., 2009) examined 41 studies published between 1996 and 2008 comparing post secondary online learning to traditional learning. Their overall conclusion from this analysis was that "on average, students in online learning conditions performed better than those receiving face-to-face instruction." However, in this analysis the online learning conditions included comparisons of fully online courses and blended or hybrid courses to F2F courses. The authors did indicate that the difference between learning outcomes when blended instruction was compared with F2F instruction was greater than those where fully online was compared to fully F2F. Due to the fact that blended instruction is very different from fully online instruction, the overall conclusions regarding online courses should be modified (Jaggars and Bailey, 2010). A further examination of the meta-analysis showed that there were 28 studies which compared fully online instruction to fully F2F and only seven of these were full semester length courses. The others were short educational interventions and may not relate to a full course (Jaggars and Bailey, 2010). Comparing learning outcomes in this smaller group of full year studies revealed no strong advantage or disadvantage to online learning (Jaggars and Bailey, 2010) which is in contrast to the original conclusions based on a mix of fully online and hybrid courses (Means et al., 2009).

In a four week cross-over comparison of quiz grades for students attending traditional lectures or online lectures in an introductory psychology course, the results showed no significant differences between the groups (Jensen, 2011). An additional third group was included in the analysis which included students who did not attend either lecture format. Quiz scores from this group of students were not significantly different from those who had attended lectures in either format. This result questions the validity of the assessments used because students who did not attend class perform as well as those who did. Possibly an assessment where lecture content was more directly assessed would result in differences among the test groups. Despite finding no differences in student outcomes, results from student surveys indicated a strong preference for the traditional lectures. Through open ended questions it was revealed that while students appreciated the convenience and ability to control the pace of the online lecture through pause and rewind functions, they also indicated that it was easy to get distracted when watching the online lecture and thus preferred the in class lecture where this was not as great an issue.

Smeaton and Keogh (1999) created online "presentations" based on the distillation of a course with forty hours of F2F lectures into eighteen hours of video lectures covering the same content. They were able to show that there were no significant differences in overall student examination performance between those who watched the video lectures and previous years when the traditional F2F format was used. The authors concluded that virtual lectures can be an effective replacement for traditional lectures.

Two studies examining both qualitative and quantitative aspects of online courses both report that there were no differences between the student outcomes (mean examination scores and project grades) for the courses examined; however, both courses reported significantly higher student satisfaction scores for the F2F course compared to the online course (Johnson et al., 2000; Hale et al., 2009). Online students scored questions dealing with interactions, both instructor and student to student, lower than those of the F2F students. Therefore, despite having no differences in student outcomes, the students perceived the experience as negative based on interaction factors. Another qualitative study echoed these studies (Grimes, 2002). Students in an online dental terminology course were surveyed for their perceptions of the course. Of the themes which emerged from these interviews, the convenience and flexibility of an online course was recurring and seen as a positive aspect of the course. Technical issues and student isolation were seen as drawbacks to online courses. The technical issues noted were not issues related to accessing the course content, however, but dealt with the incorrect auto-grading of the self tests which is a minor issue. In contrast, student isolation issues were more important and were reported as reductions in student-instructor and student-student interactions.

A blinded analysis of student work by two independent reviewers in two different courses at the graduate and undergraduate levels showed that there was no difference in the quality of work between the F2F and online sections for the undergraduate students (Dell et al., 2010). The graduate students did show some differences with certain assignments with online students outperforming the F2F students; however, the authors concluded that overall, there were no differences in student work between the delivery formats. They highlighted that the most important factor to consider in online education was the teaching methods used instead of the delivery format.

Instructor perceptions of online distance education have also been the focus of two qualitative studies (Conrad and Pedro, 2009; Schulte, 2010). These studies collected data from faculty members teaching online distance education courses across a broad range of subjects. Faculty from both studies moderated student discussion boards and communicated with students through email. The management of the discussion boards was described by the faculty as “overwhelming” (Schulte, 2010) and in addition they commented that email communication also became onerous due to other work commitments. The faculty also reported that they missed the personal interactions with the students (Conrad and Pedro, 2009). Apart from the communication and time issues mentioned, the instructors found the online courses to be equivalent to F2F with respect to student outcomes and academic rigor but with increased student accessibility for the online courses.

2.4.2.1 Blended courses

Science courses which utilize an online component to support F2F lectures are considered to be “blended” or “hybrid” in nature. A review of internet based learning in the health professions (Cook et al., 2008) has shown that, when compared to no intervention, internet based or online learning (such as Web- based tutorials, virtual patients or discussion boards) lead to improvements in student outcomes. However, when compared to other non-internet aided methods (such as computer specific CD ROMs), there was no significant improvement in learning outcomes (Cook et al., 2008). Despite the seeming lack of learning outcome benefit using internet resources, there are benefits in other areas, including increased availability of courses to students and savings on laboratory or teaching resources (Sung et al., 2008). Results from studies incorporating online components into F2F courses have shown improved outcomes (Rosenberg et al., 2006; Sung et al., 2008; McNulty et al., 2009) or no change in performance (Bryner et al., 2008; Dantas and Kemm, 2008; Mahnken et al., 2011). A study of a physiotherapy course incorporating a blended learning component showed no improvement in knowledge acquisition, however, skill acquisition was much improved, suggesting that the online component was a beneficial supplement to the F2F component (Arroyo-Morales et al., 2012). Surveys of students using these resources showed that they overwhelmingly perceived the online components as helpful (Khogali et al., 2011) despite the fact that in one study there was no actual improvement in learning outcomes (Bryner et al., 2008).

2.4.2.2 Online Laboratory Courses

Studies looking at exclusively online laboratory courses in higher education have also shown promising results. One such study compared an online laboratory on cell division with a F2F laboratory and found that the online students performed significantly better on the quiz covering that material the following week (Gilman, 2006). The authors point out some shortfalls in their study, including the presence of different instructors for the online vs F2F laboratories, which could have impacted outcomes. In addition only one laboratory session was analyzed. Similarly, a study on the effects of computer simulations in place of hands-on physics laboratory exercises showed that those students who used the computer simulations demonstrated higher learning outcomes compared to those who actually performed the experiments with the equipment (Finkelstein et al., 2005).

Another study compared student perceptions of online laboratories to F2F laboratories in a biology course (Stuckey-Mickell and Stuckey-Danner, 2007). Results showed that 86.9% of the students agreed or strongly agreed that the F2F laboratories enhanced their understanding of the course content compared to only 60.8% for the online laboratories. For all questions in their survey, F2F laboratories scored higher compared to the online laboratories. Open ended student comments suggested that the preference for the F2F laboratories was due to the perception the students can ask questions and receive immediate feedback from the instructor and/or other students which enhanced their understanding of the course content. They suggested using discussion boards and synchronous online conferencing to increase instructor communication with the students along with the incorporation of collaborative assignments to increase student to student interactions. These studies have shown that fully online laboratory courses are effective, however, some limitations may exist which relate to communications.

Finally, a comparison of a fully online histology laboratory course to a fully F2F course concluded that students in the online course outperformed the F2F students (Schoenfeld-Tacher et al., 2001). The laboratory component of the course studied involved having the students view micrographs taken at various magnifications. Although not stated, it is assumed that the F2F students used a microscope to complete their assignments, as the micrographs were supplied at various magnifications "to simulate the process of moving a microscope objective" (Schoenfeld-Tacher et al., 2001). In addition, online students were able to complete a self-assessment quiz covering the lecture content which the F2F students were not given. There were several differences between the experimental and control groups in this study in addition to the format of course delivery which may have impacted the results. Despite these differences, their results suggest that fully online histology laboratory courses have a promising future.

2.4.2.3 Summary of Online Education versus Traditional Education

Examination of studies comparing online education to traditional F2F education has shown that fully online courses can be equivalent to F2F courses with respect to learning outcomes. Learning outcomes in blended courses, with online components added to F2F courses, have been shown to improve or be equivalent to courses without the online component. Qualitative studies examining student perceptions of online courses and online laboratories gave mixed results, including negative comments focused on communication difficulties with the instructor and other students or student engagement as indicated by student's ease of distraction. In contrast, positive comments commonly cited included student's appreciation for the flexibility and control over the lecture pace the online course afforded them.

Comments about online courses from instructors were also mixed. While most agreed that these courses were of high academic standard, the main criticism from this group concerned time management issues. Instructors found the time required to moderate discussion boards and reply to student emails was at times overwhelming. A common thread between students and instructors was the challenge of effectively and efficiently communicating. The incorporation of synchronous elements into online courses, while removing some flexibility from the student, may improve the communication between instructors and students and possibly between students and other students. Future research in the area of online education should focus on methods to improve and evaluate these interactions.

2.5 Factors Affecting Student Performance

2.5.1 Previous Grades

There are many factors which will impact student performance at the post secondary level. A significant predictor of student performance is their previous academic performance. Mallik and Lodewijks (2010) showed that high school grades were significant predictors for performance in a first year economics course. In upper year post secondary education, previous performance in courses related to the course being examined have also been shown to be significant predictors of examination performance (Helle et al., 2010).

Bell (2007) examined the predictive ability of prior academic achievement based on grade point averages (GPA) of 201 students enrolled in a variety of web based courses across one post secondary institution. The results indicated that GPA was a significant predictor of course examination performance irrespective of previous online course experience. Another study found a relationship between performance on the Pharmacology College Admission Test and previous science and math grades to their performance on online modules (Ried and Byers, 2009). While this supports the predictive nature of previous grades on course performance, it should be noted that within a professional program such as the one described, all students who gain entry into the program would be strong academically. These results may not be applicable to the general undergraduate population with a wider range of academic abilities where there is a concern that weaker students may be at a disadvantage in an online course (Jaggars and Bailey, 2010). Despite the prior caution, these studies have shown that prior academic performance is an important predictor of student success in both traditional F2F and online courses.

2.5.2 Attendance

2.5.2.1 Traditional Courses

Paivio's (1971) classic book *Imagery and Verbal Processes* defines the "dual coding theory" which states that people have separate channels for processing information: visual and verbal. These channels complement each other and allow people to learn better when they are presented with information both visually and verbally. With this theory in mind, it seems probable that students who attend a lecture to receive information using both visual and verbal channels will learn better than a student who did not attend the lecture but simply read the information, using only the visual channel. There have been many studies which have tried to determine if lecture attendance has an impact on student performance. A recent meta-analysis examining 52 published papers and 16 unpublished dissertations or papers concluded that the majority of studies did show a significant positive correlation between attendance and student performance in a number of different subject areas including geography (Clark et al., 2010), pharmacy (Hidayat et al., 2012), economics (Romer, 1993; Durden and Ellis, 1995; Marburger, 2001; Zhao and Stinson, 2006) and biology (Gatherer and Manning, 1998). Durden and Ellis (1995) were able to show that student's overall attendance impacted their overall grade; while Marburger (2001) was able to show that attendance at individual lectures impacted performance on exam questions based on those lectures. A strong link between attendance at F2F lectures and course performance has been established, however, this link has not been systematically examined for online lectures.

2.5.2.2 Attendance in Online Courses

Research into the effects of attendance in online distance education has focused mainly on the impact of supplemental online instruction. Studies have examined the effects of podcasts (audio recordings of lectures) or video lecture capture that are provided to students as a supplement to live lectures (Simpson, 2006; Cramer et al., 2007; Pilarski et al., 2008). These studies found that students who used the supplemental podcasts and video lecture capture performed better on course outcome measures. The few studies which examined attendance in a fully online format were not able to show a correlation between attending the online lecture and course performance (Smeaton and Keogh, 1999; Jensen, 2011). Jensen (2011) compared quiz score results from three groups of students: those who attended in class lectures, those who attended online lectures and those who did not attend class or access online lectures. The results showed no significant differences among the groups based on quiz scores. They also showed that attendance in both online and in class lectures decreased significantly over time despite student survey results indicating that they preferred the in class lecture format. It is possible that students can gain the information tested on the quizzes from sources other than the lectures such as textbooks which would explain how students who do not attend class can score the same as the other two groups.

2.6 Student Engagement

2.6.1 Student Questions

Student questioning during laboratory or lecture times can be seen as a gauge of student–content interaction and has been linked to course performance in both F2F and online courses (Harper et al., 2003; Barak and Rafaeli, 2004). Additionally, the content of the questions can be analyzed in terms of student integration of the information. For example, a study of an undergraduate physics course analyzing questions students asked in weekly journals showed that higher cognitive level questions, which are related to a deeper understanding of the course material, were positively correlated to student performance whereas minimally cognitive level questions were negatively related to course performance (Harper et al., 2003). This same study also showed that students with a low level of incoming knowledge asked minimal cognitive level questions suggesting that students needed to attain a certain level of content proficiency in order to ask higher cognitive level questions. Online students as well have been shown to benefit from question posing exercises (Barak and Rafaeli, 2004).

Schoenfeld-Tacher (2001) analyzed student questions in online instructor–student chat sessions, F2F lectures and student led review sessions in an undergraduate histology course. They used Bloom's taxonomy (Bloom et al., 1956) to classify questions in terms of their cognitive level and found that online students had a greater proportion of high level interactions compared to the F2F students. They examined the rate (interactions per hour) and found that online interaction rate was greater than F2F; however, they were comparing a traditional lecture to a chat session which is intended as a question/answer opportunity for students. In addition, they found that the online students performed better than the F2F students on a multiple choice test given at the completion of the course. Their results suggested that the online students had better student–content interaction than the F2F students.

2.6.2 Peer teaching

The interactions between students have been shown to enhance learning, however, they are often neglected. Studies have shown that peer to peer teaching (also referred to as peer assisted learning) is an effective way to enhance learning in the laboratory setting. Evans and Cuffe (2009) have shown through surveys that the use of near-peers or senior medical students to teach junior medical students in the gross anatomy laboratory was seen to enhance anatomy learning for the less experienced students and to enhance teaching skills in the upper year students. The use of peer to peer teaching, where those in the student and instructor roles are of similar educational levels, have also shown positive results for learning in gross anatomy (Krych et al., 2005; Plendl et al., 2009) and histology (Plendl et al., 2009; Bloodgood, 2012; Shaw and Friedman, 2012) laboratories. These studies used student feedback to assess the intervention and the results showed that both gross anatomy and histology students agreed they were able to learn the material better with the incorporation of the peer teaching component despite no studies showing improved learning outcomes. One study was also able to show, through student surveys, that the role of the tutor was thought to be more beneficial to learning the material than that of the student (Plendl et al., 2009). Attempts to offer a peer teaching experience to online students have been limited to asynchronous methods, however, potential synchronous applications of peer assisted learning using a virtual classroom were suggested (Huijser et al., 2008).

2.7 Overall Summary

This review of the literature has documented the transition of a histology course from a subject taught primarily to medical students to then include undergraduate medical science students. The format of the course has also transitioned from one where students attended lectures and prepared their own laboratory materials to one where lectures remain but the laboratory material can now be accessed entirely from a computer allowing the course to be offered completely online as a distance education course. In distance education courses, the transactional distances are important interactions which must be considered for optimal student learning experiences. Research has shown that online distance education courses can produce the same learning outcomes as F2F courses and that student satisfaction with these courses is high. However, more research is needed in the area of online science courses which contain a laboratory component. Is it possible to reduce the transactional distances in a laboratory course so that it provides an equivalent learning experience to that of a F2F laboratory course?

2.8 Literature Cited

Abrami P, Bernard R, Bures E, Borokhovski E, Tamim R. 2011. Interaction in distance education and online learning: using evidence and theory to improve practice. J Comput High Educ 23:82-103.

Allen IE, Seaman J. 2010. Learning on Demand: Online Education in the United States, 2009. In, 1st Ed. ed. Newburyport, MA: Babson Survey Research Group, Sloan Consortium, Inc. p 29.

Anderson T. 2003. Getting the mix right again: An updated and theoretical rationale for interaction. In: Int Rev Res Open Dist Learn.

Arroyo-Morales M, Cantarero-Villanueva I, Fernández-Lao C, Guirao-Piñeyro M, Castro-Martín E, Díaz-Rodríguez L. 2012. A blended learning approach to palpation and ultrasound imaging skills through supplementation of traditional classroom teaching with an e-learning package. Man Ther 17:474-478.

Barak M, Rafaeli S. 2004. On-line question-posing and peer-assessment as means for web-based knowledge sharing in learning. Int J of Hum-Comp Stud 61:84-103.

Barr M. 1977. A Century of Medicine at Western. London, Ontario: The University of Western Ontario.

Bell P. 2007. Predictors of college student achievment in asynchronous web-based courses. Education 127:523-533.

Bernard R, Abrami P, Lou Y, Borokhovski E, Wade A, Wozney P, Fiset M, Huang B. 2004. How does distance education compare with classroom instruction? A meta-analysis of the emprical literature. Rev Educ Res 74:379 - 439.

Bernard RM, Abrami PC, Borokhovski E, Wade CA, Tamim RM, Surkes MA, Bethel EC. 2009. A Meta-Analysis of Three Types of Interaction Treatments in Distance Education. Rev Educ Res 79:1243-1289.

Blake CA, Lavoie HA, Millette CF. 2003. Teaching medical histology at the University of South Carolina School of Medicine: Transition to virtual slides and virtual microscopes. Anat Rec B New Anat 275:196-206.

Bloodgood R. 2012. Active learning: A small group histology laboratory exercise in a whole class setting utilizing virtual slides and peer education. Anat Sci Educ 5: 367-373.

Bloodgood RA, Ogilvie RW. 2006. Trends in histology laboratory teaching in United States medical schools. Anat Rec 289B:169-175.

Bloom BS, Engelhart MD, Furst EJ, Hill WH, Krathwohl DR. 1956. Taxonomy of Educational Objectives: The Classification of Educational Goals by a Committee of College and University Examiners. New York: David McKay Company Inc.

Braun MW, Kearns KD. 2008. Improved learning efficiency and increased student collaboration through use of virtual microscopy in the teaching of human pathology. Anat Sci Educ 1:240-246.

Bruner J. 1986. Actual Minds, Possible Worlds. Cambridge, MA: Harvard University Press.

Bryner BS, Saddawi-Konefka D, Gest TR. 2008. The impact of interactive, computerized educational modules on preclinical medical education. Anat Sci Educ 1:247-251.

Chickering AW, Gamson ZF. 1989. Seven principles for good practice in undergraduate education. Biochem Educ 17:140-141.

Clark G, Gill N, Walker M, Whittle R. 2010. Attendance and performance: Correlations and motives in lecture-based modules. J Geogr Higher Educ 35:199-215.

Coleman R. 2009. Can histology and pathology be taught without microscopes? The advantages and disavantages of virtual histology. Acta Histochem 111:1-4.

Collier L, Dunham S, Braun MW, O'Loughlin VD. 2012. Optical versus virtual: Teaching assistant perceptions of the use of virtual microscopy in an undergraduate human anatomy course. Anat Sci Educ 5:10-19.

Conrad D, Pedro J. 2009. Perspectives of online teaching and learning: A report of two novice online educators. International Journal for the Scholarship of Teaching and Learning 3.

Cook D, Levinson A, Garside S, Dupras D, Erwin P, Montori V. 2008. Internet-based learning in the health professions: A meta-analysis. JAMA 300:1181-1196.

Cooperman L. 2007. Instructional design for online course development. J Vet Med Educ 34:238-242.

Cotter JR. 2001. Laboratory instruction in histology at the University at Buffalo: Recent replacement of microscope exercises with computer applications. Anat Rec 265:212-221.

Cramer KM, Collins KR, Snider D, Fawcett G. 2007. The virtual lecture hall: Utilisation, effectiveness and student perceptions. Brit J Educ Technol 38:106-115.

Curry L. 2002. Individual differences in cognitive style, learning style and instructional preference in medical education. In: Norman GR, Van der Vleuten, C.P.M., Newble, D.I., editor. International Handbook of Research in Medical Education. Dordrecht: Kluwer Academic Publishers. p 263-276.

Dantas A, Kemm R. 2008. A blended approach to active learning in a physiology laboratory-based subject facilitated by an e-learning component. Adv Physiol Educ 32:65-75.

Dee F. 2009. Virtual microscopy in pathology education. Hum Pathol 40:1112-1121.

Dell CA, Low C, Wilker JF. 2010. Comparing student achievement in online and face-to-face class formats. MERLOT J of Online Learn Teach 6:30-42.

DiLullo C, McGee P, Kriebel RM. 2011. Demystifying the Millennial student: A reassessment in measures of character and engagement in professional education. Anat Sci Educ 4:214-226.

Drake RL, McBride JM, Lachman N, Pawlina W. 2009. Medical education in the anatomical sciences: the winds of change continue to blow. Anat Sci Educ 2:253-259.

DuFrene DD, Lehman CM, Kellermanns FW, Pearson RA. 2009. Do Business Communication Technology Tools Meet Learner Needs? Bus Commun Quart 72:146-162.

Durden GC, Ellis LV. 1995. The effects of attendance on student learning in principles of economics. Am Econ Rev 85:343-346.

Evans DJR, Cuffe T. 2009. Near-peer teaching in anatomy: An approach for deeper learning. Anat Sci Educ 2:227-233.

Felder RM, Silverman, L.K. 1988. Learning and teaching styles in engineering education. Eng Educ 78:674-681.

Finkelstein ND, Adams WK, Keller CJ, Kohl PB, Perkins KK, Podolefsky NS, Reid S, LeMaster R. 2005. When learning about the real world is better done virtually: A study of substituting computer simulations for laboratory equipment. Physical Review Special Topics - Physics Education Research 1:010103.010101-010103.010107.

Fleming N, Mills C. 1992. Not another inventory, rather a catalyst for reflection. To Improve the Academy 11:137-155.

Flowers L, White E, Raynor J. 2012. Examining the transactional distance theory in a web-enhanced biology course. J Stud Educ 2:144 - 154.

Gatherer D, Manning FCR. 1998. Correlation of examination performance with lecture attendance: A comparative study of first-year biological sciences undergraduates. Biochem Educ 26:121-123.

Gilman SL. 2006. Do online labs work? An assessment of an online lab on cell division. Amer Biol Teach 68:131-134.

Goldberg HR, Dintzis R. 2007. The positive impact of team-based virtual microscopy on student learning in physiology and histology. Adv Physiol Educ 31:261-265.

Grimes EB. 2002. Student perceptions of an online dental terminology course. J Dent Educ 66:100-107.

Hale LS, Mirakian EA, Day DB. 2009. Online vs classroom instruction: Student satisfaction and learning outcomes in an undergraduate allied health pharmacology course. J Allied Health 38:e36-e42.

Harper KA, Etkina E, Lin Y. 2003. Encouraging and analyzing student questions in a large physics course: meaningful patterns for instructors. J Res Sci Teach 40:776-791.

Harris T, Leaven T, Heidger P, Kreiter C, Duncan J, Dick F. 2001. Comparison of a virtual microscope laboratory to a regular microscope laboratory for teaching histology. Anat Rec 265:10-14.

Hassell L, Fung K, Chaser B. 2011. Digital slides and ACGME resident competencies in anatomic pathology: An altered paradigm for acquisition and assessment. J Pathol Inform 2:27.

Helle L, Nivala M, Kronqvist P, Gegenfutner A, Bjork P, Saljo R. 2011. Traditional microscopy instruction versus process-oriented virtual microscopy instruction: A naturalistic experiment with control group. Diag Path 6:S8.

Helle L, Säljö R. 2012. Collaborating with digital tools and peers in medical education: cases and simulations as interventions in learning. Instr Sci 40:737-744.

Hidayat L, Vansal S, Kim E, Sullivan M, Salbu R. 2012. Pharmacy student absenteeism and academic performance. Am J Pharm Educ 76:1-6.

Higazi TB. 2011. Use of interactive live digital imaging to enhance histology learning in introductory level anatomy and physiology classes. Anat Sci Educ 4:78-83.

Hillman DCA, Willis DJ, Gunawardena CN. 1994. Learner - interface interaction in distance education: An extension of contemporary models and strategies for practitioners. Am J Dist Educ 8:30-42.

Howe N, Strauss W. 2003. Millennials Go To College: American Association of Collegiate Registrars and Admissions Officers and LifeCourse Associates.

Huijser H, Kimmins L, Evans P. 2008. Peer assisted learning in fleximode: Developing an online learning community. Australas J Peer Lear 1:51-60.

Husmann PR, O'Loughlin VD, Braun MW. 2009. Quantitative and qualitative changes in teaching histology by means of virtual microscopy in an introductory course in human anatomy. Anat Sci Educ 2:218-226.

Jaggars S, Bailey T. 2010. Effectiveness of fully online courses for college students: Response to a Department of Education meta-analysis. Teachers College, Columbia University, Community College Research Center Web site http://ccrc.tc.columbia.edu/ (2010).

Jensen S. 2011. In-class versus online video lectures: Similar learning outcomes but a preference for in-class. Teach Psychol 38:298-302.

Johnson S, Aragon S, Shaik N, Palma-Rivas N. 2000. Comparative analysis of learner satisfaction and learning outcomes in online and face-to-face learning environments. J Interact Learn Res 11:29-49.

Khogali SEO, Davies DA, Donnan PT, Gray A, Harden RM, Mcdonald J, Pippard MJ, Pringle SD, Yu N. 2011. Integration of e-learning resources into a medical school curriculum. Med Teach 33:311-318.

Krippendorf BB, Lough J. 2005. Complete and rapid switch from light microscopy to virtual microscopy for teaching medical histology. Anat Rec 285B:19-25.

Krych AJ, March CN, Bryan RE, Peake BJ, Pawlina W, Carmichael SW. 2005. Reciprocal peer teaching: Students teaching students in the gross anatomy laboratory. Clin Anat 18:296-301.

Lundin M, Lundin J, Helin H, Isola J. 2004a. A digital atlas of breast histopathology: an application of web based virtual microscopy. J Clin Pathol 57:1288-1291.

Lundin M, Lundin J, Isola J. 2004b. Virtual Microscopy. J Clin Pathol 57:1250-1251.

Lundin M, Szymas J, Linder E, Beck H, de Wilde P, van Krieken H, García Rojo M, Moreno I, Ariza A, Tuzlali S, Dervişoğlu S, Helin H, Lehto V-P, Lundin J. 2009. A European network for virtual microscopy—design, implementation and evaluation of performance. Virchows Archiv 454:421-429.

Lutz S, Huitt W. 2004. Connecting cognitive development and constructivism: Implications from theory for instruction and assessment. Construct Hum Sci 9:67-90.

Mahnken A, Baumann M, Meister M, Schmitt V, Fischer M. 2011. Blended learning in radiology: Is self-determined learning really more effective? Eur J Radiol 78:384-387.

Mallik G, Lodewijks J. 2010. Student performance in a large first year economics subject: Which variables are significant? Economic Papers 29:80-86.

Mangold K. 2007. Educating a new generation: Teaching baby boomer faculty about millennial students. Nurs Educ 32:21-23.

Marburger DR. 2001. Absenteeism and undergraduate exam performance. J Econ Educ 32:11.

Mars M, McLean M. 1996. Students' perceptions of a multimedia computer-aided instruction resource in histology. S Af Med J 86:1098-1102.

Martin F, Parker M, Deale D. 2012. Examining interactivity in synchronous virtual classrooms. The International Review of Research in Open and Distance Learning 13.

Mayer RE. 2011. Applying the Science of Learning, 1 ed. Boston, MA: Pearson Education, Inc.

McBride T, Nief R. 2011. Mindset Lists of American History, The: From Typewriters to Text Messages, What Ten Generations of Americans Think Is Normal: Wiley.

McNulty JA, Sonntag B, Sinacore JM. 2009. Evaluation of computer-aided instruction in a gross anatomy course: A six-year study. Anat Sci Educ 2:2-8.

Means B, Toyama Y, Murphy R, Bakia M, Jones K. 2009. Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies. In: U.S. Department of Education OoP, Evaluation, and Policy Development, editor. Washington, DC.

Moore M. 1989. Editorial: Three types of interaction. Am J Dist Educ 3:1-7.

Paivio A. 1971. Imagery and verbal processes. New York: Holt, Rinehart and Winston.

Pilarski PP, Alan Johnstone D, Pettepher CC, Osheroff N. 2008. From music to macromolecules: Using rich media/podcast lecture recordings to enhance the preclinical educational experience. Med Teach 30:630-632.

Pinder KE, Ford JC, Ovalle WK. 2008. A new paradigm for teaching histology laboratories in Canada's first distributed medical school. Anat Sci Educ 1:95-101.

Plendl J, Bahramsoltani M, Gemeinhardt O, Hünigen H, Käßmeyer S, Janczyk P. 2009. Active participation instead of passive behaviour opens up new vistas in education of veterinary anatomy and histology. Anat Histol Embryol 38:355-360.

Pratt RL. 2009. Are we throwing histology out with the microscope? A look at histology from the physician's perspective. Anat Sci Educ 2:205-209.

Ried LD, Byers K. 2009. Comparison of two lecture delivery platforms in a hybrid distance education program. Am J Pharm Educ 73:95.

Romer D. 1993. Do students go to class? Should they? J Econ Perspect 7:167-174.

Rosenberg H, Kermalli J, Freeman E, Tenenbaum H, Locker D, Cohen H. 2006. Effectiveness of an electronic histology tutorial for first-year dental students and improvement in "normalized" test scores. J Dent Educ 70:1339-1345.

Schoenfeld-Tacher R, McConnell S, Graham M. 2001. Do no harm - A comparison of the effects of on-line vs. traditional delivery media on a science course. J Sci Educ Tech 10:257-265.

Schulte M. 2010. Faculty perceptions of technology distance education transactions: Qualitative outcomes to inform teaching practices. J Educ Online 7:77-101.

Scoville SA, Buskirk TD. 2007. Traditional and virtual microscopy compared experimentally in a classroom setting. Clin Anat 20:565-570.

Shachar M, Neumann Y. 2010. Twenty years of research on the academic performance differences between traditional and distance learning: Summative meta-analysis and trend examination. MERLOT J Online Learn Teach 6:318 - 334.

Shaw PA, Friedman ES. 2012. Clinico-histologic conferences: Histology and disease. Anat Sci Educ 5:55-61.

Simpson N. 2006. Asynchronous access to conventional course delivery: A pilot project. Brit J Educ Technol 37:527-537.

Sinn HP, Andrulis M, Mogler C, Schirmacher P. 2008. Virtual microscopy in pathology teaching and postgraduate training (continuing education). Pathologe 29:S255-S258.

Smeaton AF, Keogh G. 1999. An analysis of the use of virtual delivery of undergraduate lectures. Comput Educ 32:83-94.

Snyder TD, Dillow SA. 2011. Digest of Education Statistics, 2010 (NCES 2011-015) 46th Ed. In: Department of Education IoESI, National Center for Education Statistics (NCES), editor. Washington DC: URL: http://nces.ed.gov/programs.digest. p 744.

Strauss W, Howe N. 1991. Generations: The History of America's Future, 1584 - 2069, 1st ed. New York, NY: William Morrow and Company Inc.

Stuckey-Mickell TA, Stuckey-Danner, B.D. 2007. Virtual labs in the online biology course: Student perceptions of effectiveness and usability. MERLOT J Online Learn Teach 3:105-111.

Sung YH, Kwon IG, Ryu E. 2008. Blended learning on medication administration for new nurses: Integration of e-learning and face-to-face instruction in the classroom. Nurs Educ Today 28:943-952.

Travis H. 2011. Western to welcome largest first-year class. In: The University of Western Onatrio's Newspaper of Record. London, Ontario, Canada: The University of Western Ontario, Department of Communications and Public Affairs.

University of Western Ontario. 1961. Faculty of Medicine Eightieth Annual Announcement 1961- 1962. London, Ontario.

University of Western Ontario. 1997. Western Academic Calendar 1997. London, Ontario.

Usher A, Dunn R. 2009. On the Brink: How the Recession of 2009 Will Affect Post-Secondary Education. In. Toronto, ON: Educational Policy Institution.

Wedemeyer C. 1971. Independent Study. In: Deighton R, editor. Encyclopedia of Education: MacMillan. p 548-557.

Western University. 1886. Annual Announcement of the Medical Department of the Western University. London, Ontario: Free Press Printing Co.

Zhao X, Stinson TA. 2006. Motivating students for better grades: A study of the relationship between absenteeism and student performance. J Learn Higher Educ 2(2):1-8.

Chapter 3

3 Course Design and Student Outcomes

3.1 Introduction

3.1.1 Post secondary enrolment

In 2011, Western University in London, Ontario, Canada, like many other North American universities, welcomed its largest first year class in history (Snyder and Dillow, 2011; Travis, 2011). This trend of increased university enrolment is expected to continue for at least the next decade (Hango and de Broucker, 2007). As universities face increasing pressure to accept and train greater numbers of students with limited space and budgets, creative solutions must be developed to accommodate them. In this chapter, I describe the development and evaluation of a fully online undergraduate science laboratory course in microscopic anatomy (histology).

3.1.2 Online Education

Online courses are a popular option for students who are juggling courses and life outside of their studies. Growth in online course enrolment exceeds that of enrolment in higher education overall. In the United States, there was a 17% increase between 2008 and 2009 in online enrolment compared to a 1.2% increase in the overall enrolment in higher education over the same time period with 25% of all undergraduate students taking at least one online course. Millennial students (defined as individuals born between 1982 - 2003(Howe and Strauss, 2003)), who make up the current cohort of undergraduate students, have been shown to embrace technology and are a part of the force driving institutions to increase their online course offerings (Mangold, 2007; DiLullo et al., 2011). This trend is expected to continue for a number of years (Allen and Seaman, 2010) and with growth in this area of education, it is important to ensure that the online courses are of the highest quality and equivalent to the educational experience that students would receive in a traditional face to face (F2F) format.

As previously discussed in Chapter 2, section 2.3.5, online courses have undergone extensive comparisons to traditional F2F courses. A summary of the results indicate that steady improvements in student outcomes in online courses have been shown over time (Bernard et al., 2004) as instructors become more proficient teaching online and students are more comfortable taking classes online (Shachar and Neumann, 2010).

Examinations of online laboratory courses have shown mixed results as discussed in section 2.4.2.2. A summary of these findings indicates that student outcomes are improved with online laboratories (Finkelstein et al., 2005; Gilman, 2006). In contrast, student surveys have suggested that students perceived the F2F laboratories as enhancing their understanding of the material better than the online laboratories and they also indicated that their preference for the F2F laboratories was due to the perception that the students can ask questions and receive immediate feedback from the instructor and other students which enhanced their understanding of the course content (Stuckey-Mickell and Stuckey-Danner, 2007). These studies suggest that online laboratories are effective with respect to student outcomes but may have weaknesses with student-instructor communications.

3.1.3 Virtual Microscopy

The incorporation of virtual microscopy, either exclusively or in combination with traditional microscopy, has become common in the histology teaching laboratory (Bloodgood and Ogilvie, 2006; Drake et al., 2009). Its use has been credited for increased collaboration (Goldberg and Dintzis, 2007; Pinder et al., 2008; Bloodgood, 2012; Shaw and Friedman, 2012), increased learning efficiency (Krippendorf and Lough, 2005; Braun and Kearns, 2008), in addition, it has been well accepted by students (Krippendorf and Lough, 2005; Braun and Kearns, 2008; Pinder et al., 2008), and instructors (Krippendorf and Lough, 2005; Collier et al., 2012). The loss of traditional microscopy skills has been identified as a potential problem associated with the transition to virtual microscopy (Pinder et al., 2008; Coleman, 2009; Pratt, 2009); however, virtual microscopy skills have been identified as beneficial in current clinical and educational situations (Blake et al., 2003; Lundin et al., 2004a; Lundin et al., 2004b; Hassell et al., 2011; Shaw and Friedman, 2012). Virtual microscopy lends itself beautifully to the incorporation into an online course (Helle and Säljö, 2012). A thorough examination of virtual microscopy can be found in section 2.1.3.

Both traditional microscopy and virtual microscopy allow students to learn the course content in a hands-on way. They can "read" the slide to find examples of cells or structures they are assigned to find (Cotter, 2001; Bloodgood and Ogilvie, 2006). In contrast, if only textbook or atlas images are used, the evaluation component of the student's learning is lost. Typically, histology laboratories begin with a pre-laboratory talk where the instructor uses the slide collection to show the relevant cells or structures. Students then use their own microscope or virtual microscope to examine slides and complete assignments based on those slides. These exercises are active learning components which enhance a student's understanding of the material (Cotter, 2001)

There have been attempts to teach histology online with promising results (Schoenfeld-Tacher et al., 2001). The laboratory component of the course studied involved having the students view micrographs taken at various magnifications. Although not stated, it is assumed that the F2F students used a microscope to complete their assignments, as the micrographs were supplied at various magnifications "to simulate the process of moving a microscope objective"(Schoenfeld-Tacher et al., 2001). In this example, online students would lose the opportunity to evaluate the whole slide (Cotter, 2001). Despite the differences in the laboratory exercises for each format, the online student out-performed the F2F students on the assessments. A study where the laboratory exercises are more similar to each other, with only the format of delivery differing, would be a preferable way to evaluate the laboratory component of such a course.

In this chapter I will describe a new laboratory course that has been developed in an online format offering the same content as our traditional F2F histology laboratory course. Both the lecture and laboratory material are delivered using the online format. In order to ensure that the online students are receiving an experience equivalent to that of the F2F format, for both the lecture and laboratory component, this study has been designed to address the following objectives:

1. To assess student outcomes for the various assessments used in the course.
2. To assess the predictability of students' incoming grades on course outcomes in either format.

Hypothesis: Using synchronous videoconferencing software to create a virtual classroom accompanied by virtual microscopy technology, it is possible to offer an effective microscopic anatomy laboratory course to students online.

3.2 Materials and Methods

Approval to conduct this study was given by Western University's Office of Research Ethics (protocol # 17426E) (See Appendix A).

3.2.1 Virtual Slidebox

The virtual slidebox was created using the Aperio ScanScope CS (Aperio, Vista, CA) digital slide scanner. The slide collection used for the laboratory component of the F2F course (140 slides) was scanned at 40x and images were stored on a dedicated server. The presentation of the slide collection was tailored to the needs of the course. Slides were arranged into groups according to the topics covered in the laboratory outline and placed on a web page. Annotations were added to slides to highlight distinctive features of the tissues as well; text to accompany the slides described the annotations. Figure 3.1 is a screen shot of the virtual slidebox homepage. Clicking on each topic title reveals all of the slides students are to review for that topic's laboratory exercise. The virtual slidebox ensured that all students had unlimited access to the same high quality slides. Students in both the F2F and online sections of the course had access to the virtual slidebox.

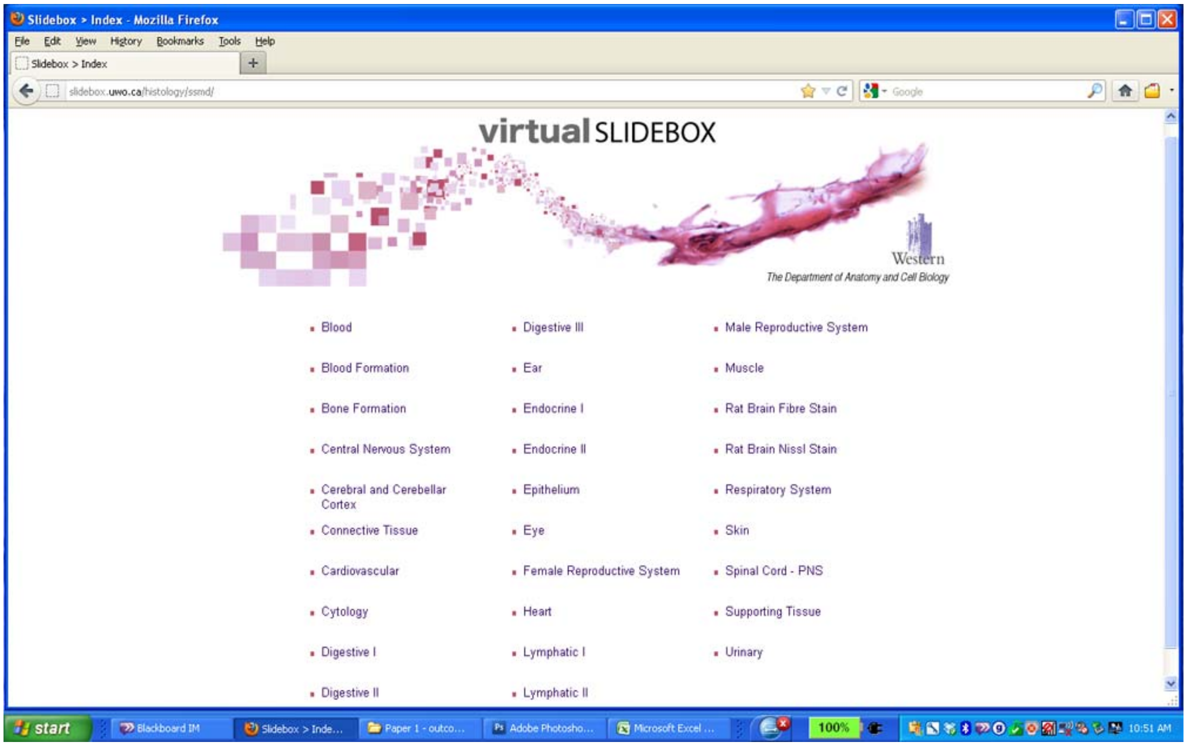

Figure 3.1: Screen shot of virtual slidebox. Each heading contains the slides covered in that topic's laboratory exercise.

.

3.2.2 Course Design

Both formats of the histology course use the WebCT platform (Blackboard Inc. Washington, DC) to organize course materials such as syllabus, notes, virtual slidebox and laboratory manual. The online version of the course has an additional icon linking to the virtual classroom, provided by Wimba Classroom (Blackboard Inc. NY, NY). A textbook and atlas were required for both groups of students (Ross and Pawlina, 2011).

The virtual classroom allows students to participate either synchronously, by joining the lecture in real time or asynchronously by watching archives of the live lectures. Students participating in the live lecture can respond to questions posed by the instructor or ask questions themselves. Due to the large size of the F2F class, a teaching assistant is placed in the audience to monitor the online students and present their questions to the professor as required.

The F2F and online lectures were given simultaneously and recorded using the virtual classroom. The equipment required was portable, available from any electronics store, and fit into a backpack. The equipment could be set up quickly and taken down in the time between lectures. The contents of the virtual classroom backpack included: 1) an HD video camera (Canon M30 HD, Canon Canada Inc. Mississauga) and tripod used to capture the instructor and any supplementary props; 2) The Pinnacle Dazzle Video Creator Plus HD (Pinnacle systems, Mountain View, CA) to convert the video signal to a digital signal; 3) A wireless microphone used for audio for both the F2F and online classes; 4) A laptop computer to connect to the virtual classroom via the internet and the classroom projector. All of the above components were connected using the appropriate cables (F2F internet, video, audio, and projector). The total additional cost for the equipment to provide the lectures both F2F and online was approximately $1,200 USD.

This course was taken by students in their third or fourth year of an undergraduate medical sciences baccalaureate program. It was offered three times over the course of this evaluation; once as a full year course over the fall/winter terms (FW; 25 weeks), and over two sequential summer terms (12 weeks each). The FW course consisted of 2 lecture hours and 3 laboratory hours per week (50 lecture hours, 75 laboratory hours, 125 total hours), while the condensed summer course consisted of 4 lecture hours and 6 laboratory hours per week (44 lecture hours, 69 laboratory hours, 113 total hours). The FW course was offered in either fully F2F (N = 115) or fully online formats (N = 44) while the summer courses were offered exclusively in the online format (N = 69). Students who did not complete either the midterm or final examination were not included in the study. There were two FW online students and four summer online students who were excluded from the study for this reason. During the FW terms students self selected which format they preferred to take. Students in the F2F course did not have access to the virtual classroom or the archived lectures but were able to access the virtual slidebox.

The F2F laboratory consisted of a pre-laboratory talk where the instructor highlighted the tissues covered in that day's topic. Following the pre-laboratory talk, the students used their microscopes with glass slides and/or the virtual slidebox to complete assignments consisting of drawings of important structures and applied questions. Students submitted their assignments by the end of the laboratory session. The online laboratory was delivered and completed entirely online. There was a pre-laboratory talk given by the instructor within Wimba Classroom to highlight the tissues of the laboratory period. The pre-laboratory talk was recorded and archived for online students not present during the live talk for access within 24 hours. The F2F students did not have access to the archives. The online assignment consisted of locating important structures using the virtual slidebox, annotating and saving images as well as answering applied questions. These assignments were submitted within 24 hours of the pre-laboratory talk.

3.2.3 Course Performance

Course outcomes were measured using the following grading system: 50% of the final grade was obtained from the laboratory component and 50% from the lecture component. The laboratory components consisted of weekly laboratory assignments, six practical quizzes and two practical examinations. The F2F students completed the laboratory assessments during the laboratory period. Laboratory quizzes and examinations were taken in a proctored environment for the F2F students, while the online students completed all laboratory components online in a non-proctored environment. The quizzes and examinations had time restrictions for both groups. Both online and F2F students received feedback on their weekly assignments and other assessment measures the week following their completion. The lecture component was assessed using two multiple choice examinations, one at the end of each term, based on the lecture material only. Both sections completed the same multiple choice examinations at the same time in proctored examination rooms.

3.2.4 Previous Grades

The majority of students taking the histology course were enroled in the undergraduate Bachelor of Medical Sciences (BMSc) or biology programs (see Table 3.1 "n" values). Administrators for the BMSc program provided grades for the second year "foundation courses" in the form of Foundation Course Averages (FCA). These courses are common to all BMSc students and include: cell biology, genetics, biochemistry, organic chemistry and statistics. Those students not enrolled in the BMSc program were not included in this portion of the study. These grades were used to determine if there is a predictive correlation between previous grades and course performance. Students were grouped according to their FCA, and each group compared among the course formats to determine if there were differences at the various grade level groupings for the final course grade as well as the total laboratory grade (Table 3.2).

3.2.5 Course Evaluations

Institution instructor and course evaluations were collected for all course sections. F2F students completed these evaluations in person during the laboratory time while FW and Summer online students were emailed institutional evaluations.

Table 3.1: Foundation Course Average (FCA) for students enroled in each course offering. N indicates the total number of students enroled in the course; (n) indicates the number of students whose FCA data were included in the study.

Students	N (n)	FCA (mean ± SD)
F2F – FW2010/11	115 (113)	75.1 ± 10.0
Online – FW2010/11	44 (43)	71.6 ± 8.3
Online Summers 2010/11 Combined	69 (66)	69.2 ± 9.0 *

* indicates a significant difference between FW F2F and Online Summer courses ($p<0.05$).

Table 3.2: Comparison of ranked incoming grades (FCA) vs final course grade and laboratory grade. There were no significant differences within each ranking among the course formats ($p > 0.05$).

FCA	FW F2F		FW Online		Summer Online	
	Final	Lab	Final	Lab	Final	Lab
< 69	62.5 (N=33)	63.2	62.8 (N=16)	70.0	62.8 (N=38)	72.9
70 - 74	72.7 (N=18)	70.5	71.9 (N=12)	74.0	71.4 (N=5)	75.4
75-79	77.5 (N=26)	79.7	77.6 (N=7)	85.5	77.0 (N=17)	79.9
80 – 89	85.0 (N=30)	84.7	83.6 (N=8)	87.3	84.6 (N=5)	92.3
> 90	92.2 (N=6)	89.8	(N=0)		96.5 (N=1)	99.0

3.2.6 Statistical Analysis

Differences between course assessment outcomes were compared using a one-way ANOVA ($p \leq 0.05$) and a Bonferroni correction to determine significant differences among the course sections. Significant correlations between previous grades and final histology course grades were determined using Pearson's correlations ($p \leq 0.05$). IBM SPSS PC 19 (Armonk, NY) was used for analysis.

3.3 Results

3.3.1 The Virtual Classroom

The simultaneous delivery of the F2F and online lectures during the FW term was facilitated through the use of the virtual classroom software Wimba Classroom. Contents of the virtual classroom backpack were used to capture the live lecture for simultaneous transmission to online students and for archival purposes. Within the virtual classroom, the video camera provided a live image of the instructor and any supplementary props that were in use, while the main screen of virtual classroom displayed the lecture slide and any annotations made by the instructor (Figure 3.2). Audio, video, and the slide presentation including annotations were captured in the archived file. In addition, the Wimba Classroom interface used for the virtual classroom lists the online students in attendance at the bottom of the screen, as well as areas where students can "raise their hands" to participate verbally and a chat area for them to communicate with the instructor or each other using text (Huijser et al., 2008)(Figure 3.2). The online students who participated in the synchronous (live streaming) lecture could ask questions in real time using these areas. Either method allows the instructor and or the teaching assistant in the classroom to respond immediately (Tagge, 2009). In addition, the instructor is able to incorporate polling questions into the lecture where students can enter their answer and the survey results can be immediately displayed. This gives an overall picture of the class responses in much the same way that 'clickers' or personal response systems are incorporated into F2F lectures to enhance learning (Mayer et al., 2009).

The weekly F2F laboratories consisted of a pre-laboratory talk where ideal photographs of the tissues being examined were briefly projected and reviewed by the instructor. The students had a laboratory outline to guide their study, their own microscope, and a complete glass slide collection as well as access to the digitized version of these slides through the virtual slidebox. During the laboratory time, the instructor and teaching assistants circulated throughout the room, answering questions and discussing slides with the students. At the completion of the laboratory, each student submitted an assignment consisting of drawings of relevant structures or tissues and answers to applied questions (Figure 3.3a).

The laboratory experience for the online students was similar to that of the F2F students, insofar as there was a pre-laboratory talk using the virtual classroom. However, online students were shown relevant images using slides from the virtual slidebox. This talk would be archived for those students who were not attending synchronously. The students would then use the laboratory outline and the virtual slidebox to complete an assignment similar to the F2F students. Instead of drawing the structures, students would have to find areas on the virtual slides, annotate and save them for submission as part of the assignment (Figure 3.3b). During the online laboratory time, the instructor remained in the virtual classroom to answer any questions or discuss slides with the students. Application sharing, a tool available in the virtual classroom, permitted the students to share their desktop with the instructor who could respond to common histology laboratory queries including "what am I looking at?" or "where can I find that feature?", mimicking the experiences of students in a F2F laboratory (Huijser et al., 2008). Those students who did not attend the synchronous laboratory session had the opportunity to ask questions through email. Analysis of student logins to the virtual classroom shows that, over the time period of the course, students took advantage of both live and archived lecture and laboratory sessions.

Figure 3.2: Image of student view of the interface of an archive from the online classroom. The main area of the screen displays the lecture content. A smaller video window (green box) displays the lecturer or can be directed to show any additional instructional aides. The lower left corner of the screen (red box) is the chat area where students can participate in the lecture using text. Along the bottom of the screen (blue box) is a list of students present along with tools such as a hand raise to alert the instructor that a student has a question. The column on the right (yellow box) displays the list of slides with time markers in the archive allowing students to fast forward or reverse through the lecture. Sample image taken from Ross and Pawlina (2011).

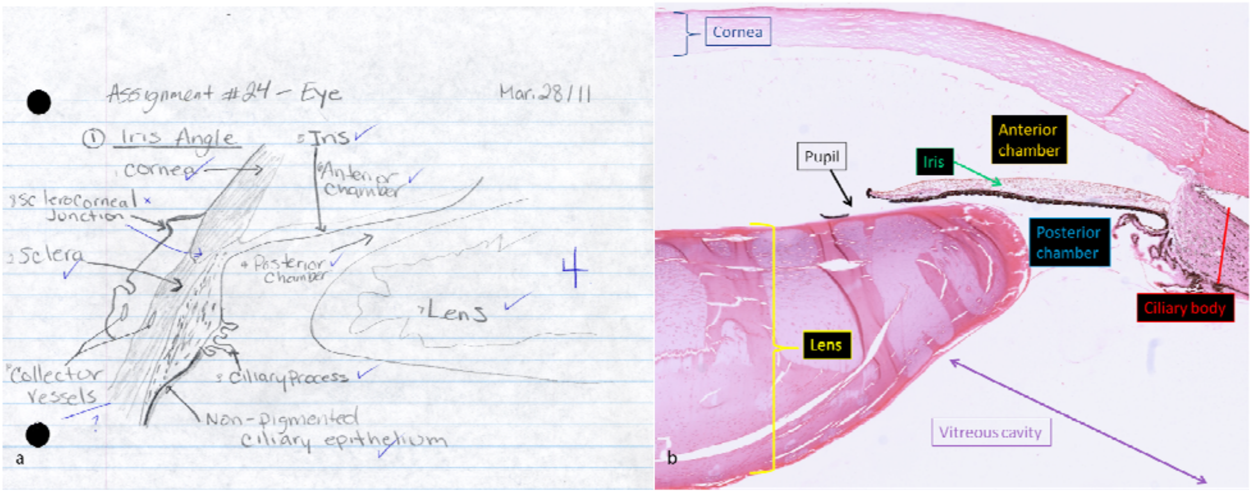

Figure 3.3: Comparison of F2F and online laboratory assignments. The images shown here are examples of typical laboratory assignments. 3.3a was drawn by a F2F student using the microscope and glass slide collection. 3.3b is an online assignment completed using annotated images from the virtual slide collection. Students are graded based on appropriately labeled structures and not artistic merit.

3.3.2 Students

Course enrolment numbers and mean FCAs are listed in Table 3.1. There were no significant differences between student FCA for the FW F2F and FW Online courses, which were offered concurrently. There was a significant difference between the FW F2F and Summer Online FCA. Although normally distributed, the grades for the Summer Online students showed a tendency for either higher achieving or weaker students in comparison to the FW Online group which showed a more even distribution (Table 3.2).

3.3.3 Student Performance

Results for each assessed outcome are given in Figure 3.4. There were no significant differences between the course outcome means for the FW F2F or FW Online formats, which were offered simultaneously. Also, despite having a significantly lower FCA for the Summer Online students, there were no significant differences among the course outcome means for any of the course sections.

3.3.4 Course Evaluations

Institutional course evaluations for online and F2F courses varied in the questions asked, however, both asked questions pertaining to student's overall satisfaction with the course. For the online evaluations, the questions pertaining to the course were averaged to give an overall grade. This grade was compared to the F2F evaluation question rating the overall effectiveness of the course. Both evaluations contained open ended questions where students were free to comment on both positive and negative aspects of the course. Table 3.3 is a summary of the number of student responses and the overall course rating. Due to the low number of online respondents, statistical comparison of the ratings was not possible. Online student comments were overall very positive with a few notes about

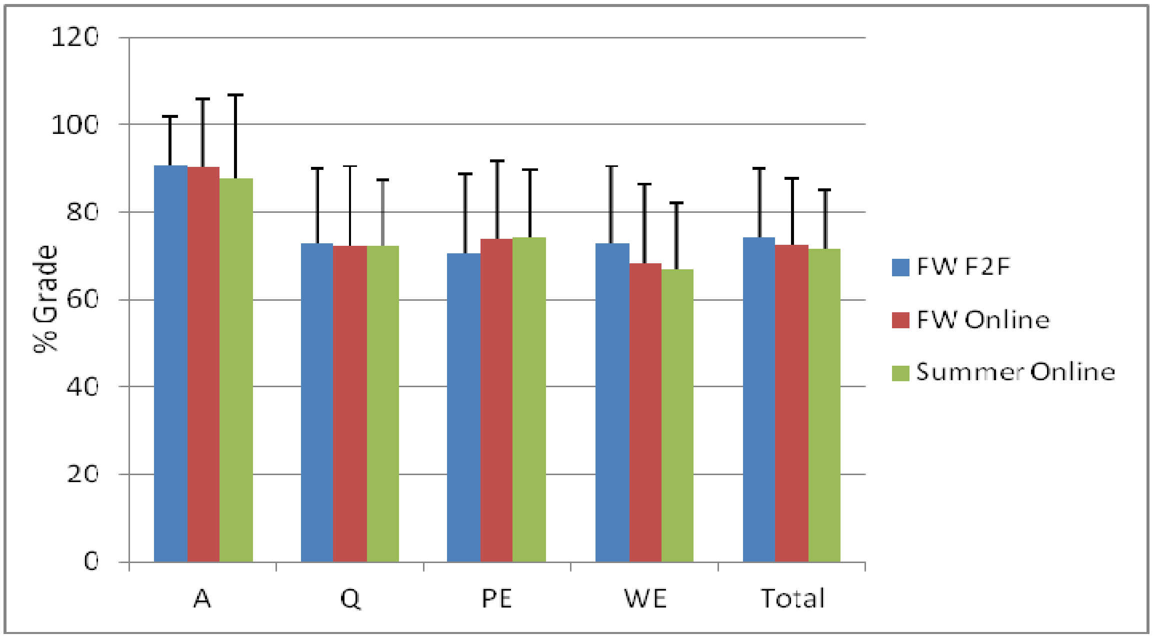

Figure 3.4: Comparison of course outcomes expressed as means ± SD for different course sections: Fall/winter F2F, Fall/winter Online and Summer Online. Course outcomes shown include assignments (A), laboratory quizzes (Q), laboratory practical examinations (PE) and written examinations (WE). Total columns represent the final grade consisting of the combined weighted grades of the previously listed outcomes.

occasional technological glitches. One online student expressed amazement at how technology had been effectively used to deliver the course:

> *"I very much enjoyed this course! I am astounded at the technologies used to enable students to take labs online and I look forward to being able to take more courses such as this one online again. The archived lectures were amazing for missed points and to be able to watch at your leisure"*

3.3.5 Previous Grades as a Predictor of Student Performance

Pearson's correlation statistics showed that there were significant, positive correlations between the FCA and the student's final course grade for each section of the course. ($p \leq 0.05$) (Figure 3.5) In general, most students performed as expected, such that individuals with historically high FCAs performed better than those with lower averages. The correlations were stronger for the FW F2F and Online Summer courses ($r(111) = .75$, $p<0.05$; $r(64) = .67$ $p<0.05$) while the correlation for the FW Online was still significant but weaker ($r(41) = .55$, $p<0.05$). Table 2 shows the final course and laboratory means for students based on their FCA grouping. There were no significant differences within each FCA grouping among the course formats for either the laboratory grade or the final course grade. Note that, in the two online groups, but not in the F2F group, several outliers could be identified where their performance was not indicative of earlier FCAs.

3.4 Discussion

This chapter describes a method of delivering an undergraduate histology laboratory course that is low-cost and easy for faculty to adopt as a teaching method. It has been

Table 3.3: Response rates and overall course score for institutional course evaluations. Overall score was based on a seven-point Likert scale where 1=very poor ranging to 7=outstanding

Course	Responses (%)	Overall Score (/7)
FW F2F	108 (93.9)	5.8 ± 1.1
FW Online	3 (6.8)	6.2 ± 0.8
Summer Online (2011 only)	13 (36)	5.5 ± 1.1

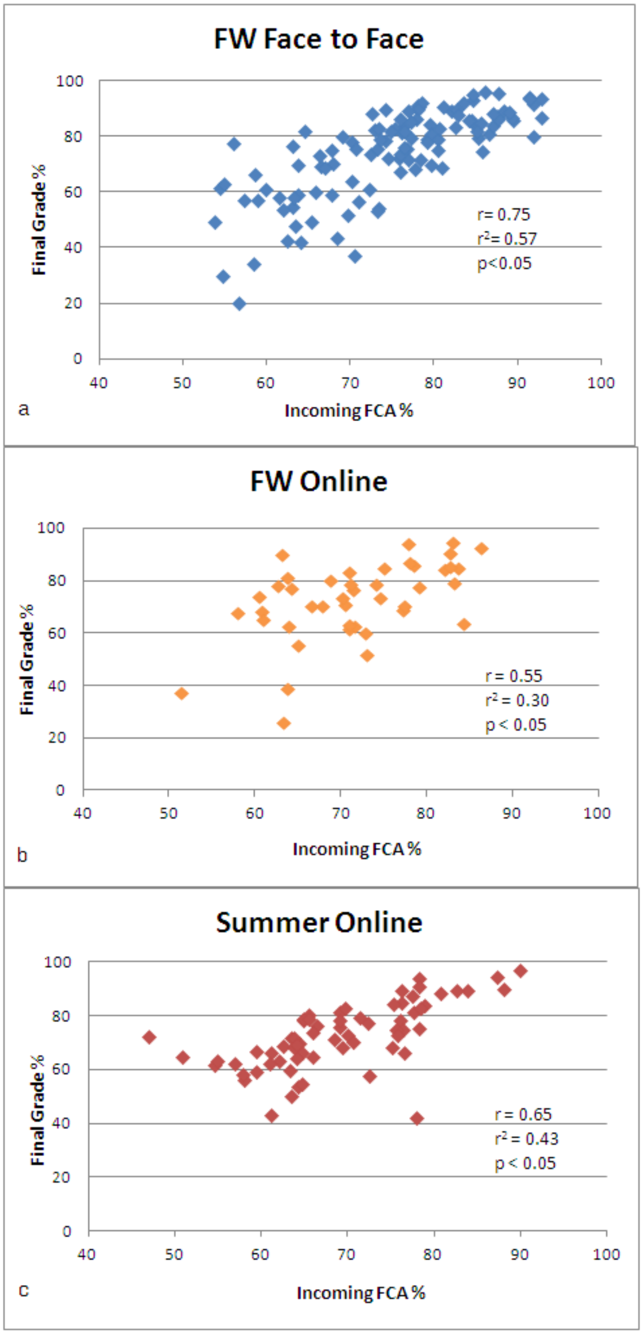

Figure 3.5: Scatter plots comparing final course grade with incoming grades (FCA) for FW F2F (a), FW Online (b) and Summer Online (c) courses. Significant positive correlations were found for all formats with stronger correlations for FW F2F (a) and Summer Online (c) compared to FW Online (b). Outliers whose FCAs were not predictive of their final course grade could be identified in both online sections (b and c).

shown that it is an effective and equivalent learning experience for students in comparison to the same F2F course. With historically high post secondary enrolments and the expectation that this trend will continue, universities must find novel methods for delivering courses as infrastructure resources approach capacity. Online courses allow students scheduling flexibility, relieve the institution's infrastructure and faculty limitations, and allow more students to enrol in courses. Virtual microscopy, commonly used to teach histology, lends itself beautifully to an online laboratory, thus making microscopic anatomy, taught with a laboratory component, ideally suited to the online environment (Sinn et al., 2008). Indeed, many studies have shown that adding an online laboratory component to a F2F course, as in a blended or hybrid course, enhances student outcomes and is well accepted by the students (Heidger et al., 2002 (Heidger et al., 2002; Rosenberg et al., 2006; Bryner et al., 2008; Dantas and Kemm, 2008; Khogali et al., 2011). The course described in this study had both lecture and laboratory components fully online, therefore, adding to the choices students have for distance education online laboratory courses in the sciences.

Provided an institution has the software license for a virtual classroom (ie: Wimba Classroom), the additional equipment required to simultaneously deliver F2F and online lectures is inexpensive and easily obtained. Institutional technical support is also required to deal with any problems that may arise. There were some initial problems with students gaining access to the virtual classroom but these were quickly resolved by adjusting computer settings. After the first week of class, there were very few student access issues.

The virtual classroom backpack allows the virtual classroom to be set up in any lecture hall with a high speed internet connection. The virtual classroom equipment can be quickly assembled or disassembled during the short time between lectures, typically 10 minutes at our institution. Instructors can easily upload presentations into the virtual classroom and use the instructor tools to annotate slides during the lecture. Teaching aids such as videos and web links commonly used to enhance traditional lectures can also be incorporated into the online classroom. In order for students to get the best experience in the online class, a high speed internet connection is required, thus preventing individuals from participating in remote underserviced areas.

For the most part, student performance in the online and F2F versions of the course were not significantly different. Despite the fact that students self selected for the course version (forced enrolment in either format would not meet institution ethical approval) there was no significant difference between these groups with respect to their FCAs. This allowed each group to be treated as initially equivalent in terms of past performance. There was a direct correlation between student's FCAs and their performance in this course irrespective of the format. The correlation was weaker for the FW Online format, possibly because of a smaller sample size or the presence of several outliers in the data set. The Summer Online students had a significantly lower FCA compared to the FW F2F students. Often, summer students are making up a missed course or one where they had performed poorly, giving this group a lower FCA. However, there were no differences in the outcome means for these students compared to the other groups.

An examination of the final grade and laboratory grade means based on student's FCA groupings also showed that students performed as expected with no differences among the course sections for any of the FCA grade ranges. This finding was especially important for students with FCA's less than 75% as online courses have been suggested to be not as effective for weaker students (Jaggars and Bailey, 2010). A previous study, comparing predictors of academic performance in distance education delivery platforms to science/math grade point average and Pharmacy College Admissions Test scores (PCAT), showed these measures to be significant predictors of performance in both test groups (Ried and Byers, 2009). However, these students were admitted to a program (Pharmacy) based on their incoming grades and PCAT scores, thus biasing the data in favor of high achieving students. Similarly, a study which examined factors which predicted medical students' performance in a microscopic pathology course found a significant correlation between the previous histology and cell biology grade and the results on microscopy examinations as well as final examination grades (Helle et al., 2010). These students would also be high achieving students for entry into medical school. In contrast, previous performance of undergraduate students examined in our study was highly variable. Despite these differences these studies found similar predictive relationships between prior performance and course outcomes.

Reductions in instructor–student and student–student interactions have been identified as possible weaknesses in online courses (Stuckey-Mickell and Stuckey-Danner, 2007; Hale et al., 2009). There is a perception that online courses inherently limit student access to the instructor, and thus weaker students taking an online course may be at a disadvantage in comparison to traditional F2F offerings (Leasure et al., 2000; Jaggars and Bailey, 2010). Similarly, limited contact with classmates may also hinder the weaker student more than a strong student. However, it has been shown that students' final course outcome was strongly correlated to their previous grades across all grade levels and therefore, the decreased interaction with instructors or other students did not seem to have an impact. Despite this finding, more research is needed to investigate effective ways to increase student engagement in the online classroom.

Students who were identified as outliers in Figure 3.5 neglected to complete major components of the course or did very poorly on assessments with high outcome weightings. While the presence of the archives for the online students allows them more flexibility to attend the lectures, it also gives those students who may be prone to procrastination the opportunity to fall behind (Donovan et al., 2006). These outliers possibly allowed themselves to get too far behind which is reflected in their grades. When designing an online course, it is important to recognize that procrastination is enabled with the archives and that frequent assessments may be required to promote timely viewing of the archives (Wesp, 1986).

Student evaluations of the course showed that all groups of students scored the courses highly. While the online student satisfaction score was higher than the F2F students', it was not possible to determine if this difference was statistically significant. Student comments also supported the overall favorable perception of the online formats; they indicated their surprise at how effective an online course can be.

Student performance indicators (see Figure 3.4) for both the lecture and various laboratory components showed that the online format and the compressed timeframe of the Summer Online course are as effective as a F2F course covering the same material. This conclusion was supported by student feedback in the course evaluations. This study also shows that a virtual classroom can be used to offer a high quality online histology laboratory as effectively as a traditional F2F microscopy laboratory using conventional microscopy with glass slides.

3.4.1 Limitations

There are several limitations to this study. It would have been preferable to randomly assign students to the experimental groups; however, as this was a study of an actual course, it would have been unethical to force students into either group. Comparison of the previous grades satisfied us that the groups were initially equal. Also, it would have been preferable to have better response rate from the online students for the course evaluation. Low survey response rates have also been described by others thought to be due to the novelty of the virtual classroom (Parker et al., 2010). The low response rate for the online students, did not allow statistical analysis of our course evaluation data.

3.5 Conclusion

A method for delivering a fully online microscopic anatomy laboratory course either on its own or in conjunction with a F2F course has been presented in this chapter. Table 3.4 summarizes the strengths and weaknesses of delivering an online histology course. Virtual classroom software, while not inexpensive, is available at most institutions. Additional equipment, which is inexpensive and readily obtainable from local electronics stores, along with minimal technological knowledge required for set up and operation, allows this course to be offered in both formats. For instructional faculty, the training required to operate the virtual classroom software is also minimal. This course is available to all students with a high speed internet connection, allowing them to overcome issues such as timetable conflicts as well as geographical and health issues which can interfere with access to traditional F2F courses. It has been shown that student performance in the FW online course is equivalent to that seen in the F2F course, including material based on the laboratory. The introduction of the online version of the course to the program has allowed enrolment to increase beyond what our physical laboratory can accommodate. It has also enabled the introduction of a summer version of the course with minimal impact on faculty as the teaching is entirely online and can be delivered from their offices on campus or at home. In summary, the capacity of this course has been increased with little impact on infrastructure and faculty time while maintaining very high educational standards.

Table 3.4: Summary of strengths and weaknesses of online histology laboratory course using Wimba Classroom and virtual microscopy software.

Online Course Strengths	Online Course Weaknesses
Inexpensive equipment for simultaneous online F2F course delivery	Initial cost of slide scanning
Synchronous or asynchronous student access	Technology support for virtual slide collection and classroom
Virtual slide collection gives uniform access to quality slides	Students require high speed internet connection for best experience
Virtual microscopy software allows slide annotation for student assignments or teaching materials (Lundin et al., 2004b; Coleman, 2009)	Reduction in student – instructor and student – student contact (Leasure et al., 2000)
Students perform as expected based on previous grades	Students do not gain microscopy skills (Pinder et al., 2008; Coleman, 2009; Pratt, 2009)
Allows increased course enrolment (Zhou and Talburt, 2011)	

3.6 Literature Cited

Allen IE, Seaman J. 2010. Learning on Demand: Online Education in the United States, 2009. In, 1st Ed. ed. Newburyport, MA: Babson Survey Research Group, Sloan Consortium, Inc. p 29.

Bernard RM, Abrami PC, Lou Y, Borokhovski E, Wade A, Wozney L, Wallet PA, Fiset M, Huang B. 2004. How Does Distance Education Compare With Classroom Instruction? A Meta-Analysis of the Empirical Literature. Rev Educ Res 74:379-439.

Blake CA, Lavoie HA, Millette CF. 2003. Teaching medical histology at the University of South Carolina School of Medicine: Transition to virtual slides and virtual microscopes. Anat Rec B New Anat 275:196-206.

Bloodgood R. 2012. Active learning: A small group histology laboratory exercise in a whole class setting utilizing virtual slides and peer education. Anat Sci Educ 5:367-373.

Bloodgood RA, Ogilvie RW. 2006. Trends in histology laboratory teaching in United States medical schools. Anat Rec 289B:169-175.

Braun MW, Kearns KD. 2008. Improved learning efficiency and increased student collaboration through use of virtual microscopy in the teaching of human pathology. Anat Sci Educ 1:240-246.

Bryner BS, Saddawi-Konefka D, Gest TR. 2008. The impact of interactive, computerized educational modules on preclinical medical education. Anat Sci Educ 1:247-251.

Coleman R. 2009. Can histology and pathology be taught without microscopes? The advantages and disavantages of virtual histology. Acta Histochem 111:1-4.

Collier L, Dunham S, Braun MW, O'Loughlin VD. 2012. Optical versus virtual: Teaching assistant perceptions of the use of virtual microscopy in an undergraduate human anatomy course. Anat Sci Educ 5:10-19.

Cotter JR. 2001. Laboratory instruction in histology at the University at Buffalo: Recent replacement of microscope exercises with computer applications. Anat Rec 265:212-221.

Dantas A, Kemm R. 2008. A blended approach to active learning in a physiology laboratory-based subject facilitated by an e-learning component. Adv Physiol Educ 32:65-75.

DiLullo C, McGee P, Kriebel RM. 2011. Demystifying the Millennial student: A reassessment in measures of character and engagement in professional education. Anat Sci Educ 4:214-226.

Donovan C, Figlio D, Rush M. 2006. Cramming: The effects of school accountability on college-bound students. National Bureau of Economic Research Working Paper Series Working paper.

Drake RL, McBride JM, Lachman N, Pawlina W. 2009. Medical education in the anatomical sciences: the winds of change continue to blow. Anat Sci Educ 2:253-259.

Finkelstein ND, Adams WK, Keller CJ, Kohl PB, Perkins KK, Podolefsky NS, Reid S, LeMaster R. 2005. When learning about the real world is better done virtually: A study of substituting computer simulations for laboratory equipment. Physical Review Special Topics - Physics Education Research 1:010103.010101-010103.010107.

Gilman SL. 2006. Do online labs work? An assessment of an online lab on cell division. Amer Biol Teach 68:131-134.

Goldberg HR, Dintzis R. 2007. The positive impact of team-based virtual microscopy on student learning in physiology and histology. Adv Physiol Educ 31:261-265.

Hale LS, Mirakian EA, Day DB. 2009. Online vs classroom instruction: Student satisfaction and learning outcomes in an undergraduate allied health pharmacology course. J Allied Health 38:e36-e42.

Hango D, de Broucker P. 2007. Postsecondary Enrolment Trends to 2031: Three Scenarios. In, 1st ed. Ottawa, Canada: Culture, Tourism and the Centre for Education Statistics Division. p 108.

Hassell L, Fung K, Chaser B. 2011. Digital slides and ACGME resident competencies in anatomic pathology: An altered paradigm for acquisition and assessment. J Pathol Inform 2:27.

Heidger PM, Dee F, Consoer D, Leaven T, Duncan J, Kreiter C. 2002. Integrated approach to teaching and testing in histology with real and virtual imaging. Anat Rec 269:107-112.

Helle L, Nivala M, Kronqvist P, Ericsson KA, Lehtinen E. 2010. Do prior knowledge, personality and visual perceptual ability predict student performance in microscopic pathology? Med Educ 44:621-629.

Helle L, Säljö R. 2012. Collaborating with digital tools and peers in medical education: cases and simulations as interventions in learning. Instr Sci 40:737-744.

Howe N, Strauss W. 2003. Millennials Go To College: American Association of Collegiate Registrars and Admissions Officers and LifeCourse Associates.

Huijser H, Kimmins L, Evans P. 2008. Peer assisted learning in fleximode: Developing an online learning community. Australas J Peer Lear 1:51-60.

Jaggars S, Bailey T. 2010. Effectiveness of fully online courses for college students: Response to a Department of Education meta-analysis. Teachers College, Columbia University, Community College Research Center Web site http://ccrc.tc.columbia.edu/ (2010).

Khogali SEO, Davies DA, Donnan PT, Gray A, Harden RM, Mcdonald J, Pippard MJ, Pringle SD, Yu N. 2011. Integration of e-learning resources into a medical school curriculum. Med Teach 33:311-318.

Krippendorf BB, Lough J. 2005. Complete and rapid switch from light microscopy to virtual microscopy for teaching medical histology. Anat Rec 285B:19-25.

Leasure AR, Davis L, Thievon SL. 2000. Comparison of student outcomes and preferences in a traditional vs. World Wide Web-based baccalaureate nursing research course. J Nurs Educ 39:149-154.

Lundin M, Lundin J, Helin H, Isola J. 2004a. A digital atlas of breast histopathology: an application of web based virtual microscopy. J Clin Pathol 57:1288-1291.

Lundin M, Lundin J, Isola J. 2004b. Virtual Microscopy. J Clin Pathol 57:1250-1251.

Mangold K. 2007. Educating a new generation: Teaching baby boomer faculty about millennial students. Nurs Educ 32:21-23.

Mayer RE, Stull A, DeLeeuw K, Almeroth K, Bimber B, Chun D, Bulger M, Campbell J, Knight A, Zhang H. 2009. Clickers in college classrooms: Fostering learning with questioning methods in large lecture classes. Contemp Educ Psychol 34:51-57.

Parker M, Grace E, Martin F. 2010. Do you teach in a virtual classroom?: Measuring student's perceptions of the features and characteristics. Int J Inst Tech Dist Educ 7:17-28.

Pinder KE, Ford JC, Ovalle WK. 2008. A new paradigm for teaching histology laboratories in Canada's first distributed medical school. Anat Sci Educ 1:95-101.

Pratt RL. 2009. Are we throwing histology out with the microscope? A look at histology from the physician's perspective. Anat Sci Educ 2:205-209.

Ried LD, Byers K. 2009. Comparison of two lecture delivery platforms in a hybrid distance education program. Am J Pharm Educ 73:95.

Rosenberg H, Kermalli J, Freeman E, Tenenbaum H, Locker D, Cohen H. 2006. Effectiveness of an electronic histology tutorial for first-year dental students and improvement in "normalized" test scores. J Dent Educ 70:1339-1345.

Ross M, Pawlina W. 2011. Histology: A text and atlas with correlated cell and molecular biology, 6th ed. Philadelphia, PA: Lippencott Williams and Wilkins.

Schoenfeld-Tacher R, McConnell S, Graham M. 2001. Do no harm - A comparison of the effects of on-line vs. traditional delivery media on a science course. J Sci Educ Tech 10:257-265.

Shachar M, Neumann Y. 2010. Twenty years of research on the academic performance differences between traditional and distance learning: Summative meta-analysis and trend examination. MERLOT J Online Learn Teach 6:318 - 334.

Shaw PA, Friedman ES. 2012. Clinico-histologic conferences: Histology and disease. Anat Sci Educ 5:55-61.

Sinn HP, Andrulis M, Mogler C, Schirmacher P. 2008. Virtual microscopy in pathology teaching and postgraduate training (continuing education). Pathologe 29:S255-S258.

Snyder TD, Dillow SA. 2011. Digest of Education Statistics, 2010 (NCES 2011-015) 46th Ed. In: Department of Education IoESI, National Center for Education Statistics (NCES), editor. Washington DC: URL: http://nces.ed.gov/programs.digest. p 744.

Stuckey-Mickell TA, Stuckey-Danner BD. 2007. Virtual labs in the online biology course: Student perceptions of effectiveness and usability. MERLOT J Online Learn Teach 3:105-111.

Tagge N. 2009. Jing and Yang: Balancing asynchronous and synchronous training. Lib Hi Tech News 10:6-7.

Travis H. 2011. Western to welcome largest first-year class. In: The University of Western Onatrio's Newspaper of Record. London, Ontario, Canada: The University of Western Ontario, Department of Communications and Public Affairs.

Wesp R. 1986. Reducing procrastination through required course involvement. Teach Psychol 13:128-130.

Zhou Y, Talburt JR. 2011. Campus-centric distance education using Wimba Live Classroom. In: IT in Medicine and Education (ITME), 2011 International Symposium on. p 713-716.

Chapter 4

4 Do Lectures Matter?

4.1 Introduction

Institutions are offering increasing numbers of online courses each year and students are enrolling in these courses in ever greater numbers (Snyder and Dillow, 2011). With this increase in enrolment and course offerings, there is a concern that the quality of these courses may not be on par with the face to face (F2F) counterparts. I have previously shown that there were no differences in student outcomes when comparing an online histology course with laboratory to the same F2F course. I did note that there appeared to be some differences in how the students approached the course with respect to attendance.

Paivio's (1971) classic book *Imagery and Verbal Processes* defines the "dual coding theory" which states that people have separate channels for processing information: visual and verbal. These channels complement each other and allow people to learn better when they are presented with information both visually and verbally. With this theory in mind, it seems probable that students who attend a lecture to receive information using both visual and verbal channels will learn better than a student who did not attend the lecture but simply reads the information, using only the visual channel.

There have been many studies which have tried to determine if lecture attendance has an impact on student performance. A recent meta-analysis examining 52 published papers and 16 unpublished dissertations or papers concluded that the majority of studies did show a significant positive correlation between attendance and student performance (Credé et al., 2010). Specific studies have shown that attendance is directly related to course performance in a number of different subject areas including geography (Clark et al., 2010), pharmacy (Hidayat et al., 2012), economics (Romer, 1993; Durden and Ellis, 1995; Marburger, 2001; Zhao and Stinson, 2006) and biology (Gatherer and Manning, 1998). However, this link has not been well established for the online or Virtual Classroom.

Students in the online virtual classroom are separated from the instructor and other students both by both space and time. Moore described teaching in the distance classroom, which would include the online classroom as not just an "aberration from the classroom but as a significantly different pedagogical domain" (Moore, 2007). He recognized that there were differences between teaching in the distance classroom compared to the traditional F2F classroom. The theory of transactional distance describes the interactions between the learner and the course content, learner and instructor and learner and other learners (Moore, 1989) all of which will be impacted by learning in a distance education classroom. It is the interaction between the learner and instructor who are separated both physically and possibly temporally which may have the greatest impact on the student. Because the student is already separated from the instructor by these factors, it is possible that the effects of attendance in an online class may have a different impact than what has been seen in the F2F classroom.

Research into the effects of attendance in online distance education has focused mainly on the impact of supplemental online instruction. Studies have examined the effects of podcasts (audio recordings of lectures) or video lecture capture that are provided to students as a supplement to live lectures (Simpson, 2006; Cramer et al., 2007; Pilarski et al., 2008). These studies found that students who used the supplemental podcasts and video lecture capture performed better on course outcome measures. The few studies which examined attendance in a fully online course format were not able to show a correlation between attending the online lecture and course performance (Smeaton and Keogh, 1999; Jensen, 2011).

In this chapter I report on our study to determine if there is a link between lecture attendance and student performance for students in a fully online histology course. In order to examine this relationship, the following objectives have been developed:

1. To compare differences in student attendance levels between online and F2F formats
2. To analyze patterns in initial and repeat archive access for online students
3. To compare attendance with overall student outcomes for both online and F2F students
4. To compare individual lecture attendance with exam performance for both online and F2F students
5. To assess whether multiple archive views results in improved exam performance for online students

4.2 Methods

Approval to conduct this study was given by Western University's Office of Research Ethics (protocol # 17426E) (See Appendix A).

4.2.1 Course Details

Chapter 3 describes the development and details of the online histology laboratory course. This course was offered concurrently in two formats: F2F and online. Both formats covered the same content and were offered during the Fall/Winter session (FW) as well as an online only version during the summer session. During the FW session, there were a total of 49 one hour F2F lectures given twice weekly over the 25 week session. These lectures were captured using Wimba Classroom software (Blackboard Inc., NY) which archived all PowerPoint slides, instructor annotations of these slides, any additional embedded video, video of the instructor and any live online questions. The online students could choose to attend these lectures live, by logging in during the live presentation, or they could access the archive at a more convenient time. They also had the opportunity to access the archive multiple times while the F2F students could only attend the initial live lecture. All students were provided with copies of the lecture slides and notes which accompany the lectures which were posted on the course management site. A textbook/atlas was also recommended for the students (Ross and Pawlina, 2011) During the summer session, the course was condensed into 43 hours of lectures over 13 weeks or up to four lecture hours per week. The number of students who completed the course for each session was: FW F2F 116; FW Online 44; Summer Online 73.

4.2.2 Attendance

Attendance was measured in the F2F class by passing clipboards with class lists throughout the lecture hall during the lecture and having students voluntarily initial beside their name. Online attendance was recorded by Wimba Classroom log in records, which included the name, date, time and length of stay for each archived lecture. This information was downloaded at the end of each term after all assessments were completed. Any log in over 5 min was considered attendance and further classified as either a first view or an additional view.

4.2.3 Exam questions

One of the primary assessment measures for these courses was two multiple choice exams which covered the material taught in the lectures. These exams were given at the midterm (after lecture 25) and end of the course (after lecture 49). They were non-cumulative and together accounted for 50% of the student's final course grade. The remaining 50% of the grade was from weekly laboratory assignments, six laboratory quizzes and two laboratory practical exams. Each multiple choice question on the written exams was based on material from individual lectures (75 from midterm and 72 from final; 2 questions from the final exam were excluded because they were based on multiple lectures). The exam question index score (EQIS) was determined for each lecture using the following formula:

$$EQIS = 1 - \frac{\#incorrect\ questions\ from\ individual\ lecture}{\#\ questions\ from\ individual\ lecture}$$

The mean EQIS was determined for students who attended or viewed the lecture 0, 1, 2, 3, or ≥ 4 views. Table 4.1 shows the number of cases (# of students x # of lectures) used to determine the EQIS for each attendance category. All exam questions could have been answered correctly using material covered in the class notes, the PowerPoint lecture slides available online and recommended textbook even if a student had not attended lectures.

4.2.4 Statistical Analysis

Differences between course attendance and EQIS were detected using a one-way ANOVA ($p \leq 0.05$) and a Bonferroni correction to determine significant differences between the course sections or the number of archive views. Differences between attendance quartile final grades were determined using a one-way ANOVA ($p \leq 0.05$) and a Bonferroni correction to determine significant differences. Significant correlations between attendance and written exam grades were determined using Pearson's correlations ($p \leq 0.05$). IBM SPSS PC 19 (Armonk, NY) was used for analysis

4.3 Results

There were no significant differences in the assessments for any of the formats offered ($p > 0.05$) (Table 4.2). This table is a summary of data from Figure 3.4. Student outcomes have been analyzed in detail in Chapter 3.

Table 4.1: Number of cases (exam questions X students) for each attendance grouping

	0 Views	**1 view**	**2 views**	**3 views**	**4+ Views**
FW F2F	1943	3117			
FW Online	382	774	465	220	206
Summer Online	1054	991	504	225	181

Table 4.2: Course assessment grades (mean % ± SD). FW F2F is fall/winter face to face, FW online is fall/winter online and summer online is the course offered in the online format only during the summer academic session. Laboratory assessments included laboratory assignments, quizzes and practical examinations. Written exam is the combined grade of both midterm and final examinations. Final grade is the combined weighted average laboratory assessments and written examinations.

Course format	**Laboratory Assessments**	**Written Examinations**	**Final Grade**
FW F2F	75.6 ± 15.3	72.9 ± 17.7	74.2 ± 15.6
FW Online	76.5 ± 16.4	68.4 ± 17.8	72.4 ± 15.1
Summer Online	76.0 ± 14.1	67.1 ± 15.2	71.6 ± 13.5

There were no significant differences among the course formats for any of the assessments ($p>0.05$).

4.3.1 Overall Attendance

Over the timeframe of the full course, attendance levels for both formats fluctuated (Figure 4.1). For the F2F students there was a drop in attendance around the midterm in each half of the course (lectures13-19 and lectures 38-43). Overall attendance in the F2F class decreased over the course while online attendance was more stable. The overall mean attendance for the online students (79.3% ± 1.3) was significantly greater than that for the F2F students (61.6% ± 1.7; $p<0.05$).

Students in the F2F class had only one opportunity to see the professor present the material, which was at the scheduled time for the live lecture. The online students, however, had online access to the live lectures as well as archives of these lectures which allowed them to view the lectures at a later time for as many times as they wished. Figure 4.2 shows the attendance patterns for the first viewing of a lecture by the online students. The overall online attendance curve is the same as that in Figure 4.1, however, the data has been subdivided into three time periods within which students first attended or viewed the lecture. There was considerable variation in the attendance patterns over the timeframe of the course with sharp decreases midway through each term (Lectures 13 and 38). However, lecture attendance recovered shortly after the midterms through the use of archives.

The presence of the archives not only gave students flexibility in terms of when they attended the lecture, but it also provided them with the opportunity to review the lecture material. There was high repeat archive access for the initial lectures, however, repeat archive access declined throughout the course (Figure 4.3a). Figure 4.3b represents the number of students who accessed the archives for a second time (or more) within seven days of the examination. There is variation over the period of the course with more students reviewing the material in the second term in comparison to the first term. Figure 4.3c represents the number of students who accessed the lectures for the first time seven days before the examination, which represents individuals who waited until just before the examination to view the lectures. Note that students have delayed their attendance more in the second term when compared to the first term.

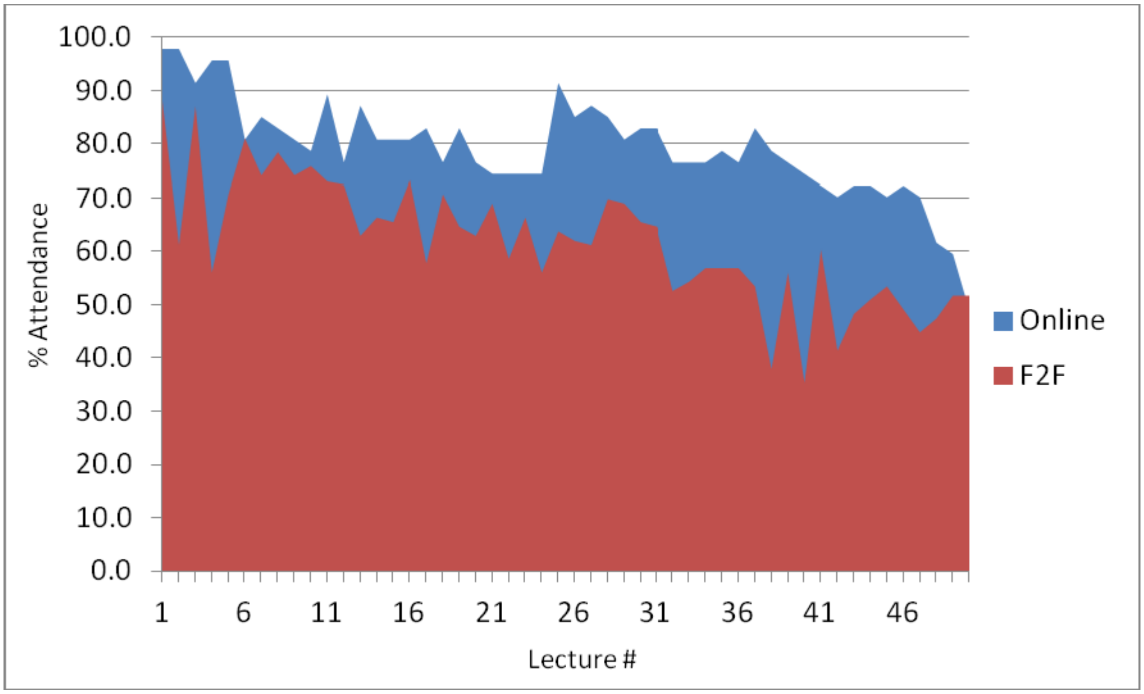

Figure 4.1: Overall attendance of Fall/Winter online and face to face (F2F) lectures. Attendance levels for both formats fluctuated over the course. F2F attendance levels decreased in the middle of each term but recovered somewhat prior to the exams at Lectures 25 and 49. Overall mean attendance for online format (79.3% ± 1.3) was significantly greater than attendance for the F2F format (61.6% ± 1.7; $p<0.05$).

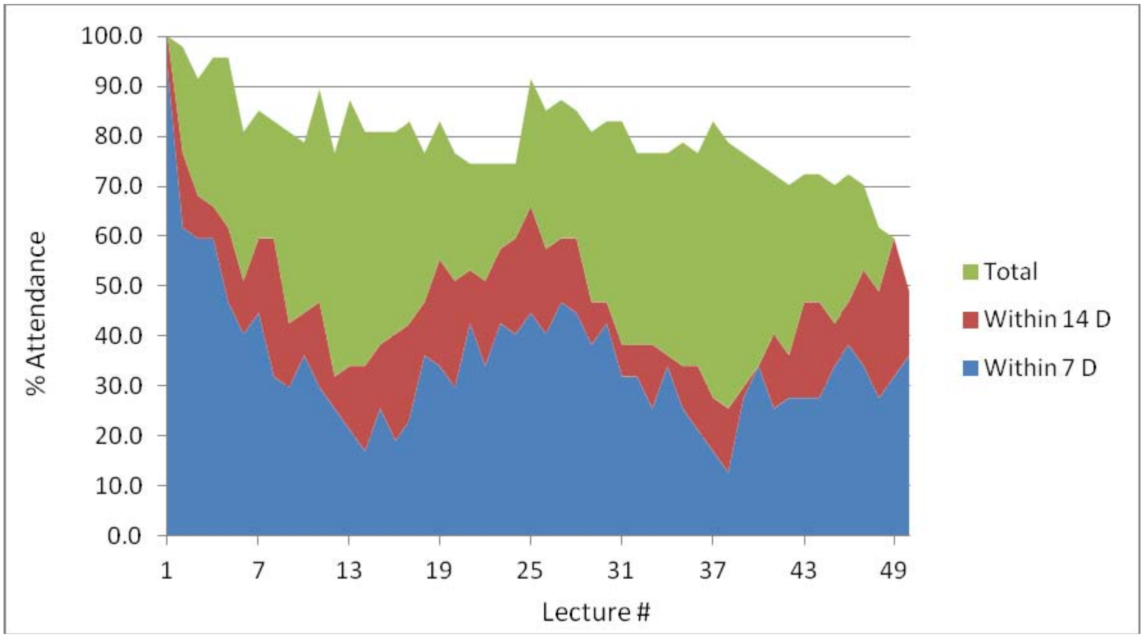

Figure 4.2: Online attendance. Percent of class who accessed lectures for the first time live or within seven days of the live lecture (blue), within 14 days of the live lecture (red) or before the end of term (green). There was a large decrease in lecture access within 7 days of the lecture around each midterm period (Lectures 13 and 38) however, attendance levels recovered through the use of archives.

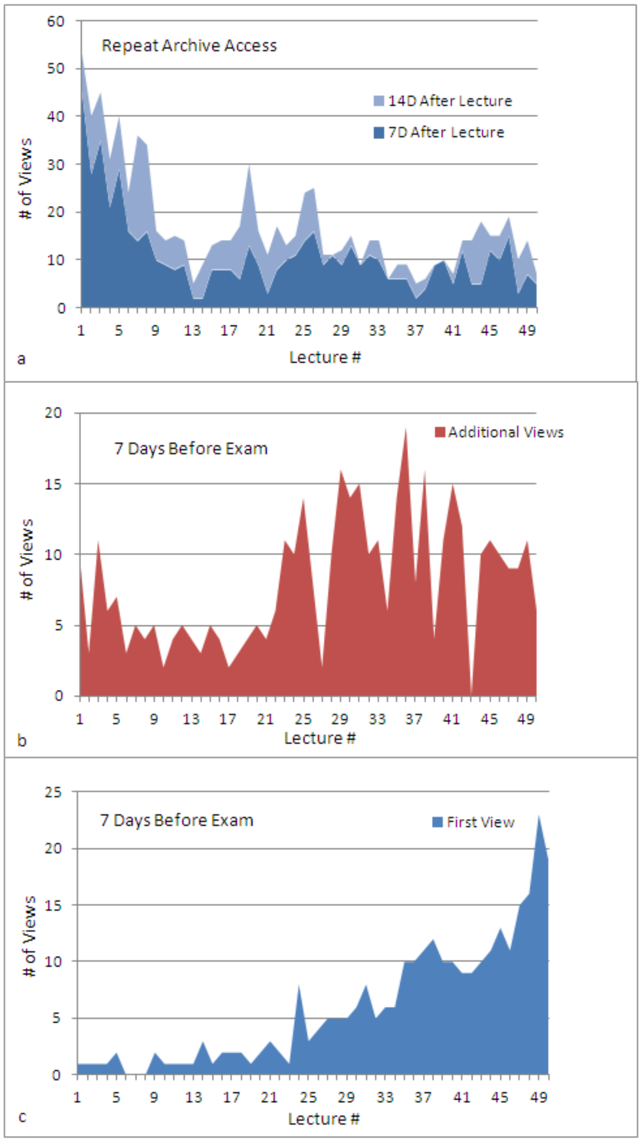

Figure 4.3: **Archive Access. Examinations were given after lectures 25 and 49. a represents the number of students who accessed the archive in addition to the initial viewing 7 and 14 days following the live lecture. Repeat access was high for the initial lectures but declined throughout the course. b represents the number of students who accessed the archives for repeat viewing 7 days before the examinations. Repeat viewing increased during the second half of the course. c represents the number of students who accessed the archives for the first time 7 days prior to the examination. Few students delayed their initial viewing of the lectures until just before examinations in the first term, however, more students delayed access to the second term lectures.**

4.3.2 Influence of Attendance on Grades

There was a significant positive correlation between the number of classes attended and the overall grade on the written exams for the F2F students ($r = 0.46$ $p < 0.05$) (Figure 4.4a) and the FW online students ($r = 0.47$; $p = 0.001$, Figure 4.4b). However, there was no significant correlation between the total number of archive views (which includes the initial and repeat archive views) and the overall grade on the written exams for the FW online students ($r = 0.29$ $p = 0.054$) (Figure 4.4c).

F2F and online students were divided into quartiles based on the number of lectures attended and by the total number of archive views for the online students (Table 4.3). For the written exam means, there was a significant difference between the lowest (62.4% ± 17.5) and highest (82.6% ± 12.4) attending quartile for the F2F students ($p < 0.05$). However, there were no significant differences for written exam means among quartiles for the FW Online students for either the number of lectures attended or the total number of archive views.

The EQIS was used as a measure of the impact of individual lecture attendance on exam performance. Figure 4.5 shows the EQIS values versus attendance (either lecture attendance or online lecture views). F2F students have only one opportunity to attend the lectures, thus attendance versus non-attendance is compared. There was a significant difference in the EQIS between those students who attended and those students who missed lectures ($p < 0.05$). For the online students, in addition to comparing attendance vs non-attendance, the impact of multiple archive views can also be assessed. There was a significant difference in the EQIS between students who did not view or attend the lectures and those who did in both the FW ($p < 0.05$) and summer ($p < 0.05$) sessions. However, there were no significant differences between EQISs for those who viewed lectures once compared to those who viewed two, three, or four or more times.

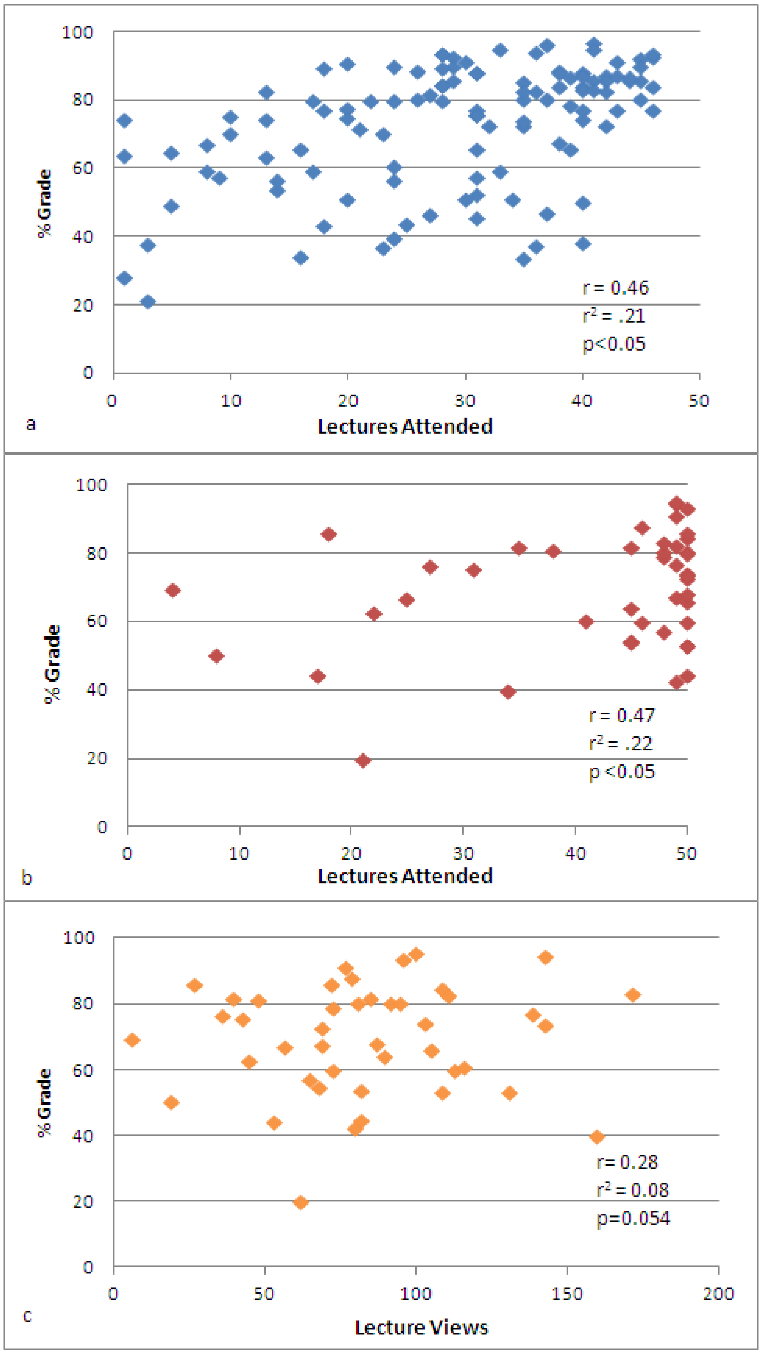

Figure 4.4: Correlation plots for overall attendance vs written examination grade. There was a significant positive correlation between overall F2F attendance and written exam grade (r=0.46; p<0.05) (a) and online attendance and written exam grade (r=0.47; p<0.05) (b); however, there was no correlation between the total number of online lecture views (initial and repeat views) and written exam grade (r=0.29; p=0.054) (c).

Table 4.3: Written examination grades (mean % ± SD) based on lowest to highest attendance grouped into quartiles.

Attendance Quartile (%)	F2F	Online Initial view	Online Total views (initial + repeat)
0 - 25	62.4 ± 17.5	61.1 ± 20.3	64.8 ± 19.8
26 -50	73.9 ± 17.8	69.0 ± 12.8	70.7 ± 15.7
51 - 75	72.9 ± 17.1	68.0 ± 18.6	72.8 ± 15.6
76 - 100	82.6 ± 12.4*	79.4 ± 9.6	69.2 ± 16.9

***indicates significantly different from lowest attending quartile (0-25%) $p<0.05$.**

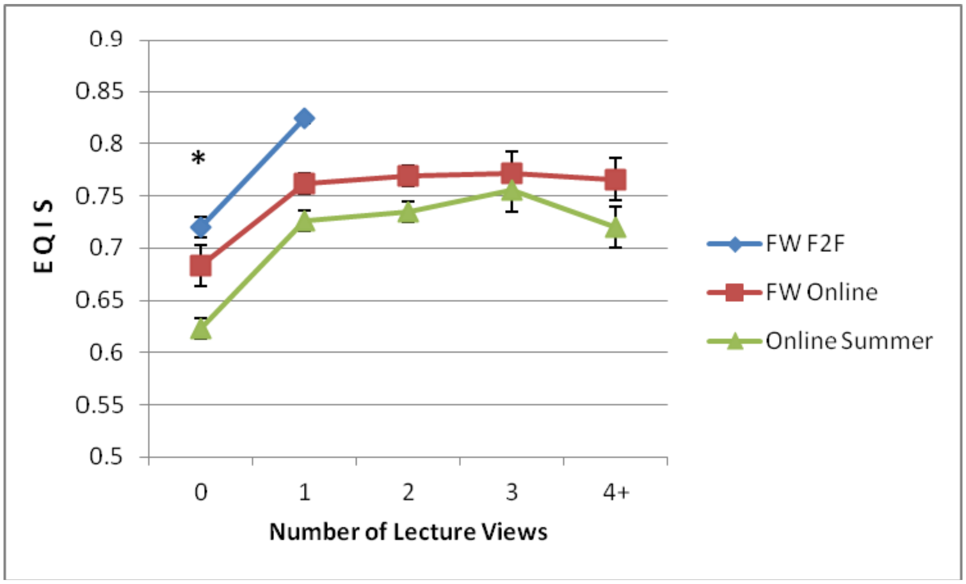

Figure 4.5: Exam Question Index Score (EQIS) vs number of lecture views for Fall/winter F2F, Fall/winter online and summer online formats (mean ± SE). There was a significant difference in the EQIS for students who attended or viewed the lecture compared to those who did not (* indicates significantly different from 1, 2, 3, or 4 or more views $p<0.05$). There was no significant difference for both FW and Summer online students who viewed lecture archives 1, 2, 3, or 4 or more times ($p>0.05$).

4.4 Discussion

This study compared the attendance of students in an online histology laboratory course to those of in a F2F course covering the same content. The impact of both overall and lecture by lecture attendance on student performance was examined.

4.4.1 Overall Attendance

Our results indicate that despite considerable attendance variations in each term, the online students had significantly greater overall attendance compared to the F2F students (Figure 4.1). When the archive access for the online students is examined (Figure 4.2), the number of students who attended live or viewed the archive within 7 days of the live lecture varied over each term with a marked drop in attendance at each midterm (approximately lectures 13 and 38). The majority of courses that students in this program were studying concurrently with our course required students to sit an exam mid-way through each term. The course I am reporting held its exams at the end of each term. Drops in attendance in our course coincide with the times when the students would have given priority to mid-term exams and/or assignments in their other courses. The presence of the archive allowed the students the scheduling flexibility to focus on other work and then "catch up" with the missed lectures at a later time as can be seen with archive views either within 14 days of the live lecture or sometime before the end of the term. This gives the online students an overall higher attendance rate than F2F students who do not have the opportunity to view missed lectures.

It has been demonstrated numerous times and in many disciplines that lecture attendance in a F2F course is positively correlated with student outcomes (Romer, 1993; Durden and Ellis, 1995; Gatherer and Manning, 1998), including a meta-analysis which concluded that attendance was the most important predictor of college grades (Credé et al., 2010). The results for F2F lectures agree with these previous studies; I have shown that overall attendance is positively correlated with overall student performance (Figure 4.4a) which is in agreement with others who showed similar results for economics (Romer, 1993) and pharmacy (Hidayat et al., 2012) courses.

When the written exam means for the lowest to highest attending quartiles were compared (Table 4.3), there was a significant increase in written exam grade for the quartile with the highest attendance ($p<0.05$). It was also shown that there was a significant correlation between online lecture attendance and written exam grades ($p<0.05$) (Figure 4.4b); however, there was not a significant correlation between the total number of online archive views and written exam grades ($p=0.054$) (Figure 4.4c). An analysis of individual lecture attendance and exam performance using the EQIS demonstrated a significant association between students who attended lectures and their performance on exam questions based on those lectures (Figure 4.5). These results are in agreement with those found by Marburger (2001) who used a similar micro approach to examine the relationship between lecture absence and exam performance on questions based on individual lectures in an economics course. He demonstrated that students who missed a lecture performed poorly on questions based on those lectures.

Little is known about the relationship between online lecture attendance and student outcomes. Limited studies have shown that the use of supplemental online materials either has no effect (Wandel, 2010) or positive effects (Cramer et al., 2007; Grabe and Christopherson, 2008; White, 2009) on course performance. Another study, more similar to the current study, showed that when students missed F2F lectures but were able to make up the missed class using an archive of that lecture, those with greater overall attendance had an increased rank in the course compared to those who did not use the lecture archive (Whitley-Grassi and Baizer, 2010). Their course would be considered a blended or hybrid course where both F2F and online lecture options exist for students, whereas, the current study delivered lectures either fully online or fully F2F with supplemental online notes available to both. The Whitley-Grassi and Baizer (2010) study does highlight the effectiveness of the archive in allowing students greater flexibility for viewing lectures which ultimately leads to increased overall attendance. Our study also showed that students were able to use the archives to make up for online lectures that they did not attend live or within the week after they were given, thus leading to overall greater attendance levels for the online courses.

Using lecture archives, students were able to review lecture material after the lecture or just prior to examinations. At the beginning of the course, a greater number of students accessed the lecture archive subsequent to the initial viewing during the beginning of the course, and less so during the remaining lectures. This likely represents students becoming familiar with the use of the archive to take notes and learn the material, thus reducing their need for subsequent viewings. Repeat use of the archives increased seven days before the examinations (Figure 4.3b) as students prepared for these assessments. In addition, there was greater repeat use of the archive in the second term compared to the first term, possibly due to the increased complexity of the material in the second term.

In contrast, the archive also enabled students to procrastinate as is illustrated by the number of students accessing the archives for the first time seven days before the examination (Figure 4.3c). A study surveying student attitudes toward online and F2F courses asked if students disliked the class because it was "easy to get behind" (Elvers et al., 2003). The responses showed that 90% of the online students did find it "easy to get behind" compared to 56% in the F2F group. This study also developed a procrastination score for each student based on the number of days between the date the course material was first accessed and the test date. Despite no differences in the procrastination score between the online and F2F students, they found that increased procrastination was negatively correlated to the exam scores for the online students but not the F2F students. Another study surveyed students on their reasons for selecting either the online or F2F format (Leasure et al., 2000). Students indicated that they chose the F2F section because of the perception of decreased opportunities for procrastination. A report examining patterns of first time student download of online lectures also showed a marked increase in activity just before the midterm exams (Donovan et al., 2006). Procrastination in online courses cannot be ignored as a possible barrier to optimal student performance.

Online instructors and course designers must be aware that the archives will allow some students to leave initial viewing of the material until just before the exam. The effects of procrastination may be less pronounced in a F2F environment because the student who attended the lecture but has not looked at the material since that time, has had at least one exposure to the topic (and potentially more if the information is built upon in other lectures) (Elvers et al., 2003). Regular assessments have been shown to help students manage their time more effectively in online courses (Wesp, 1986) and should be considered in order to reduce procrastination.

Results from the current study showed that multiple archive views did not result in greater exam performance (Figure 4.5). One might postulate that if lecture attendance leads to an increase in exam performance then possibly viewing the lectures multiple times would lead to greater improvements. However, data from our study are in agreement with the study of Smeaton and Keogh (1999) who found no relationship between multiple accesses to course material and improvements in grades. In addition, a similar plateau was seen in a study examining the supplemental use of video review lectures (Cramer et al., 2007). The sum of video access time for the study period was determined for each student with a mean duration of 75.9 min (± 91.7) and a range from 5 to 566 minutes. Students who accessed the material for 100 – 150 minutes (which is greater than the mean) increased their exam grades by an average of 15%. However, students who accessed the material for greater than 150 minutes (which is at least two times the mean) did not show any increased improvement in their scores. It is possible that when students attend a lecture in an online environment, there may be distracters (such as roommates or background noise) that are not present in the lecture hall (Jensen, 2011). Therefore, even though they are “attending” the online lecture, they may not be giving it their full attention, thus necessitating multiple accesses to the archives.

I did not survey students on their motivation for accessing the archives after their initial viewing; however, some students may be actively looking to clarify a specific concept while others may be trying review the overall lecture with no specific goal in mind. The latter may not be an effective use of student’s time. A study which examined archive use in a hybrid course where students could attend live lectures and have additional access to lecture archives found that high achieving students made minimal use of the archives while low achieving students viewed entire lecture archives multiple times (Owston et al., 2011). These results support the findings in this study that multiple repeated viewings of the lecture archives do not necessarily result in improved grades.

Two studies where repeated archive use has been shown to be beneficial were in a subpopulation of students whose mother tongue was not English (Simpson, 2006; Pearce and Scutter, 2010). Students in these studies reported using the archives “frequently” to clarify information from the class which was not initially understood. Further research is needed in this area to determine who benefits the most from the archives and how students of differing abilities utilize this resource.

Finally, it is important for the online lecturer or course designer to keep student engagement in mind when designing the lecture. Frequent opportunities to keep the student’s attention should be incorporated throughout the lecture possibly through polling questions or other more interactive learning activities. For hybrid courses these techniques may minimize the need to revisit the lecture archives due to loss of focus during the lecture. This is an important teaching technique for any F2F lecture but may be even more important in the online environment.

4.4.2 Limitations

Online attendance was determined based on virtual classroom log in records which simply indicated that the student had logged into the classroom; currently, there is no way to determine if the student was “attending” to the lecture material or simply logging in and multitasking.

F2F attendance was measured by having students voluntarily initial beside their name on class lists passed throughout the lecture hall. It is not known how many students (if any) chose not to indicate their presence.

4.5 Conclusion

In this study, a fully online histology laboratory course was compared to a F2F course covering the same content. It was shown that the presence of archived lectures gave students greater flexibility and resulted in increased overall attendance rates compared to F2F students. In addition, despite both groups of students having full access to lecture slides and notes, our results established that there was a positive impact on examination performance with online and F2F lecture attendance. The results suggested, however, that repeated access to the archives does not result in improved exam performance. More research is needed to determine which groups of students can benefit from archives and how they can best utilize this resource to optimize their study time. Further, online lectures need to be developed which will increase student engagement and course designers should incorporate frequent assessments to help students avoid procrastination. Finally, students must recognize the differences that exist between F2F lectures and the online course environment and determine strategies to avoid potential pitfalls to help them to be successful in their development.

4.6 Literature Cited

Clark G, Gill N, Walker M, Whittle R. 2010. Attendance and performance: Correlations and motives in lecture-based modules. J Geogr Higher Educ 35:199-215.

Cramer KM, Collins KR, Snider D, Fawcett G. 2007. The virtual lecture hall: Utilisation, effectiveness and student perceptions. Brit J Educ Technol 38:106-115.

Credé M, Roch SG, Kieszczynka UM. 2010. Class attendance in college. Rev Educ Res 80:272-295.

Donovan C, Figlio D, Rush M. 2006. Cramming: The effects of school accountability on college-bound students. National Bureau of Economic Research Working Paper Series Working paper.

Durden GC, Ellis LV. 1995. The effects of attendance on student learning in principles of economics. Am Econ Rev 85:343-346.

Elvers GC, Polzella DJ, Graetz K. 2003. Procrastination in online courses: Performance and attitudinal differences. Teach Psychol 30:159-162.

Gatherer D, Manning FCR. 1998. Correlation of examination performance with lecture attendance: A comparative study of first-year biological sciences undergraduates. Biochem Educ 26:121-123.

Grabe M, Christopherson K. 2008. Optional student use of online lecture resources: Resource preferences, performance and lecture attendance. J Comput Assist Lear 24:1-10.

Hidayat L, Vansal S, Kim E, Sullivan M, Salbu R. 2012. Pharmacy student absenteeism and academic performance. Am J Pharm Educ 76:1-6.

Jensen S. 2011. In-class versus online video lectures: Similar learning outcomes but a preference for in-class. Teach Psychol 38:298-302.

Leasure AR, Davis L, Thievon SL. 2000. Comparison of student outcomes and preferences in a traditional vs. World Wide Web-based baccalaureate nursing research course. J Nurs Educ 39:149-154.

Marburger DR. 2001. Absenteeism and undergraduate exam performance. J Econ Educ 32:11.

Moore M. 1989. Editorial: Three types of interaction. Am J Dist Educ 3:1-7.

Moore M. 2007. The Theory of Transactional Distance. In: Moore M, editor. Handbook of Distance Education, 2nd ed. Mahwah, NJ: Lawrence Erlbaum Associates Inc. p 89-105.

Owston R, Lupshenyuk D, Wideman H. 2011. Lecture capture in large undergraduate classes: Student perceptions and academic performance. Internet Higher Educ 14:262-268.

Paivio A. 1971. Imagery and verbal processes. New York: Holt, Rinehart and Winston.

Pearce K, Scutter S. 2010. Podcasting of health sciences lectures: Benefits for students from a non-English speaking background. Australas J Educ Technol 26:1028-1041.

Pilarski PP, Alan Johnstone D, Pettepher CC, Osheroff N. 2008. From music to macromolecules: Using rich media/podcast lecture recordings to enhance the preclinical educational experience. Med Teach 30:630-632.

Romer D. 1993. Do students go to class? Should they? J Econ Perspect 7:167-174.

Ross M, Pawlina W. 2011. Histology: A text and atlas with correlated cell and molecular biology, 6th ed. Philadelphia, PA: Lippencott Williams and Wilkins.

Simpson N. 2006. Asynchronous access to conventional course delivery: A pilot project. Brit J Educ Technol 37:527-537.

Smeaton AF, Keogh G. 1999. An analysis of the use of virtual delivery of undergraduate lectures. Comput Educ 32:83-94.

Snyder TD, Dillow SA. 2011. Digest of Education Statistics, 2010 (NCES 2011-015) 46th Ed. In: Department of Education IoESI, National Center for Education Statistics (NCES), editor. Washington DC: URL: http://nces.ed.gov/programs.digest. p 744.

Wandel AP. 2010. Student usage of videos containing worked solutions. In: Gardiner A, editor. AaeE 2010: Past, Present, Future - the 'Keys' to Engineering Education Research and Practice. Sydney, Australia: Australasian Association for Engineering Education. p 301-306.

Wesp R. 1986. Reducing procrastination through required course involvement. Teach Psychol 13:128-130.

White BT. 2009. Analysis of students' downloading of online audio lecture recordings in a large biology lecture course. J Coll Sci Teach:5.

Whitley-Grassi N, Baizer JS. 2010. Video lecture capture in physiology courses: Student attendance, video viewing and correlations to course performance. Inter J Instruct Technol Dist Learn 7:31-37.

Zhao X, Stinson TA. 2006. Motivating students for better grades: A study of the relationship between absenteeism and student performance. J Learn Higher Educ 2(2):1-8.

Chapter 5

5 Student Engagement

5.1 Introduction

As enrolment in post secondary distance education courses continues to increase in response to budgetary and student demands (Allen and Seaman, 2010), it is important to ensure that these courses are providing the same high quality educational experience as a traditionally delivered face to face (F2F) course would provide. There is the perception that there is decreased interaction, lack of immediate feedback and less meaningful learning opportunities associated with internet based (online) distance education courses (Leasure et al., 2000). I have developed a fully online senior level histology laboratory course which can be offered either alone or concurrently with a F2F course covering the same content. This current study addresses some of the perceptions associated with online course instructor feedback and interaction. In addition, I have introduced a method to enhance learner–learner interactions and evaluated its impact in terms of student outcomes and student feedback.

5.1.1 Distance Education

The interactions in a distance education classroom were described by Moore (1989) as the learner-content, learner-instructor and learner-learner interactions. A full description of these interactions can be found in section 2.3.4. The current chapter focused on the learner-instructor and learner-learner interactions.

5.1.2 Peer teaching

Typically at Western University, laboratory teaching assistants are graduate students who have previously completed the course or an equivalent and are therefore competent with the content but not yet at an expert level. These students are more advanced in their knowledge of the subject than the students they are teaching and would represent "near-peers". Another example of near peers would be upper year students teaching more junior students such as in a Medical program. It has been shown that teaching from these near peers in the gross anatomy laboratory results in benefits for both student and near peer teacher (Evans and Cuffe, 2009). The use of reciprocal peer teaching has also been investigated in the gross anatomy laboratory setting (Krych et al., 2005). Reciprocal peers are individuals who are at the same knowledge level as their classmates and take turns teaching each other. This study of reciprocal peers found that 100% of the students found that peer teaching increased their understanding of the topics, 97% thought that it increased their retention of the information they presented and 92% thought that it improved their communication skills.

5.1.3 Laboratory Based Questions

Student questions posed during laboratory or lecture times can be seen as a gauge of learner–content interaction. Student questioning has been directly linked to course performance in both F2F and online courses (Harper et al., 2003; Barak and Rafaeli, 2004). Additionally, the content of the questions can be analyzed in terms of student integration of the information. For example, a study of an undergraduate physics course where questions students asked in weekly journals were analyzed, showed that higher cognitive level questions, which are related to a deeper understanding of the course material, were positively correlated to student performance, whereas minimally cognitive level questions were negatively related to course performance (Harper et al., 2003). This same study showed that students with a low level of incoming knowledge (based on pretest scores) primarily asked minimally cognitive level questions, suggesting that students needed to attain a certain level of content proficiency in order to ask the higher cognitive level questions. Online students have also been shown to benefit from question posing exercises (Barak and Rafaeli, 2004).

Schoenfeld-Tacher (2001) analyzed student questions in online instructor–student chat sessions, F2F lectures and student led review sessions in an undergraduate histology course. They used Bloom's taxonomy (Bloom et al., 1956) to classify questions in terms of their cognitive level and found that online students had a greater proportion of high level interactions compared to the F2F students. They examined the rate of questioning (interactions per hour) and found that it was also greater for the online students. However, they were comparing a traditional lecture, where there would be few questions, to a chat session, which is intended as a question/answer opportunity for students. In addition, they found that the online students performed better than the F2F students on a multiple choice test given at the completion of the course. Their results suggested that the online students had better learner–content and learner-instructor interactions than the F2F students.

The current study examined the learner–instructor interactions during the laboratory period and proposed a method for synchronous peer teaching for both online and F2F histology laboratories. It is thought that in the online classroom, the student's interactions with the instructor and other students would be less than in those in the F2F classroom. Therefore, the hypothesis of this study was that there is a greater transactional distance in the online course. To address this hypothesis, the following objectives were developed:

1. To compare the types and rates of student questions during the online versus F2F laboratories
2. To determine if peer teaching has an impact on student laboratory outcomes for both online and F2F students.
3. To compare online and F2F student perceptions of the impact of peer teaching in the histology laboratory.

5.2 Materials and Methods

Approval to conduct this study was given by Western University's Office of Research Ethics (protocol # 17426E) (See Appendix A).

5.2.1 Course Description

The development and assessment of the online histology course has been previously described in Chapter 3. For this study, senior undergraduate medical science baccalaureate students from the fall/winter 2011 academic year self selected which version of the course they enrolled in: F2F (N=137) or online formats (N=58). The course consisted of 49 hours of lecture delivered twice weekly for 25 weeks. The laboratory component consisted of 25 weekly 3 hour sessions where F2F students used microscopes and/or virtual microscopy while the online students relied exclusively on virtual microscopy. The virtual microscope contained a digitized version of the F2F slide collection; therefore, both groups of students had access to the same slide sets.

The F2F laboratory consisted of a pre-laboratory talk where the F2F instructor highlighted the tissues covered in that day's laboratory period. Following the pre-laboratory talk, the students used their microscopes or virtual microscopes to complete assignments consisting of drawings of important structures and applied questions. Students submitted their assignments by the end of the laboratory session. While the students worked on their assignments, teaching assistants circulated throughout the room and answered any questions which may have arisen.

The online instructor used Wimba Classroom (Blackboard Inc. NY, NY) virtual classroom software to deliver the pre-laboratory talk. During this talk, the instructor highlighted the tissues for that day's laboratory period. This pre-laboratory talk was recorded and archived for online students who could not attend the live demonstrations. Online students were given 24 hours to access the recording, if they had not attended live, and complete the assignment. The F2F students did not have access to the archives. Following the pre-laboratory talk, the instructor remained online in the virtual classroom for a total of three hours to answer any questions posed by the students while they completed their assignments. The instructor also answered questions through email for those students who watched the asynchronous recording. The online assignment consisted of saving an image in which important structures had been located using the virtual microscope and annotated, and answering applied questions. These assignments were submitted within 24 hours of the live pre-laboratory talk. Students also had the opportunity to communicate with each other through asynchronous discussion boards.

The laboratory component of the course included six practical quizzes given over the duration of the course and two practical exams given at the end of each term. For the F2F students, these consisted of projected images with a time limit to answer each question in a proctored environment. The online students completed their laboratory exams and quizzes online in a non-proctored environment with similar images to those used for the F2F students, presented in a time limited fashion. The laboratory component of the course contributed 50% of the student's final course grade. Of that 50%, the assignments comprised 10%, quizzes 20% and the exams 20%. The remaining 50% of the final course grade was derived from two written exams based on the lecture material.

5.2.2 Laboratory Questions Assessment

For three consecutive laboratory sessions, teaching assistants in both the F2F and online courses monitored student questions. Each question was coded into one of the following topic categories:

- **Identification** – questions regarding the simple identification of a structure on the microscope or virtual microscope
- **Simple comprehension** – any question where a simple explanation of the structure is sufficient to answer the question, such as the difference between two structures
- **Complex comprehension** – any question where a more complex explanation is required, such as describing the structure - functional relationship of the area in question

- **Technical** – any question dealing with microscope or computer issues
- **Administrative** – questions regarding the administration of the course such as exam dates or grading issues
- **Other** – all questions of a non-academic or social nature not dealing with the course content

Laboratory assessment outcomes including assignments, quizzes and practical examinations were also compared for online and F2F students.

5.2.3 Peer Teaching

The peer teaching exercise was introduced to the students at the beginning of the second term of the course. The peer teaching was conducted weekly for the duration of the second term.

Peer teaching groups in the F2F laboratory consisted of students sitting together at work benches, 8 students maximum per group. Following the instructor led pre-laboratory talk, students were given the weekly assignment to be completed before the lab session ended. Beginning in the second term, students were also assigned individual slides to present to their group members. Groups would congregate around one computer and the presenter would use the virtual microscope to show the important structures of the assigned slide. No marks were given for this portion of the lab. Teaching assistants circulated during the presentations to encourage participation, to ensure accuracy and to answer questions the presenter may not be able to respond to. The group presentations lasted approximately 15 min after which time students returned to the completion of their assignments.

To form the online peer teaching groups, students selected one of several time slots according to their preference. Groups were organized based on common time slots and these groups remained the same for the duration of the second term. Prior to the peer teaching exercises, students were given the opportunity to learn how to use the virtual classroom as a presenter, which included uploading presentations and using the annotation tools available. Students were assigned one or two slides (the same as the F2F group) to prepare and upload into the virtual classroom ahead of the assigned meeting time. When the group met, each member did their slide presentations which were archived. The teaching assistant would either attend the group session live or watch the archive to ensure accuracy and provide any feedback to the groups.

At the end of the term, online and F2F students were invited to participate in a survey examining student perceptions of the peer teaching sessions (Appendix B). Online students were able to complete the survey through email while the F2F students had the opportunity to complete the survey in person during their laboratory time. Questions in the survey asked students to rate the effectiveness of attending or giving the presentation in terms of a learning experience. The survey also contained a qualitative assessment of student's perceptions of the exercise. Responses were collated and examined for common themes.

5.2.4 Student Performance

Student overall laboratory outcomes were compared to those of the previous year, prior to the introduction of peer teaching (online N = 44, F2F N = 115) (Table 5.1). Outcomes examined were for the laboratory components only.

5.2.5 Statistical Analysis

To determine significant differences in student laboratory outcomes a one-way ANOVA was performed with a Bonferroni correction to determine significant differences among the groups ($p \leq 0.05$).

5.3 Results

5.3.1 Laboratory Questions Assessment

Laboratory question data was collected over three laboratory periods at the beginning of the second term. The ratio of questions:students was 1.1 for the online students and 0.45 for the F2F students, indicating that the F2F students asked fewer questions as a whole. For F2F students, questions which required a simple explanation were the most commonly asked while identification questions were the most commonly asked by the online students (Figure 5.1). There were no questions requiring a complex explanation for the online students. There were few questions of a technical nature at this point in the course. Both online and F2F students had similar levels of non-course related or social questions. The mean laboratory grades for the online students (87.0 ± 10.0%) were significantly greater than those for the F2F students (81.4 ± 11.6%) $p = 0.04$ (Figure 5.2).

5.3.2 Peer Teaching

The final student laboratory grade outcomes for the online and F2F students with and without peer teaching indicated that there was a significant improvement in laboratory grades with peer teaching (Figure 5.2). The online students increased their laboratory grade by 9.4% ($p=0.002$) while the F2F students increased their grade by 5.8% ($p=0.003$) with the peer teaching intervention. The impact of peer teaching was greater with the online students with a 5.6% higher laboratory grade ($p=0.04$) compared to the F2F students both who had peer teaching.

Both classes were invited to participate in a survey at the completion of the course (Table 5.2). 57% of the F2F students compared to 14% of the online students completed the survey. Due to the low number of online student responses, data are given as percentages. Of those students surveyed, 53% of the F2F and 37% of online students reported that they had participated in at least 50% of the peer teaching sessions. The

Table 5.1: Number of students enrolled in each section for the peer teaching comparison

	F2F	Online
Peer Teaching (FW 2011)	137	58
No Peer Teaching (FW 2010)	115	44

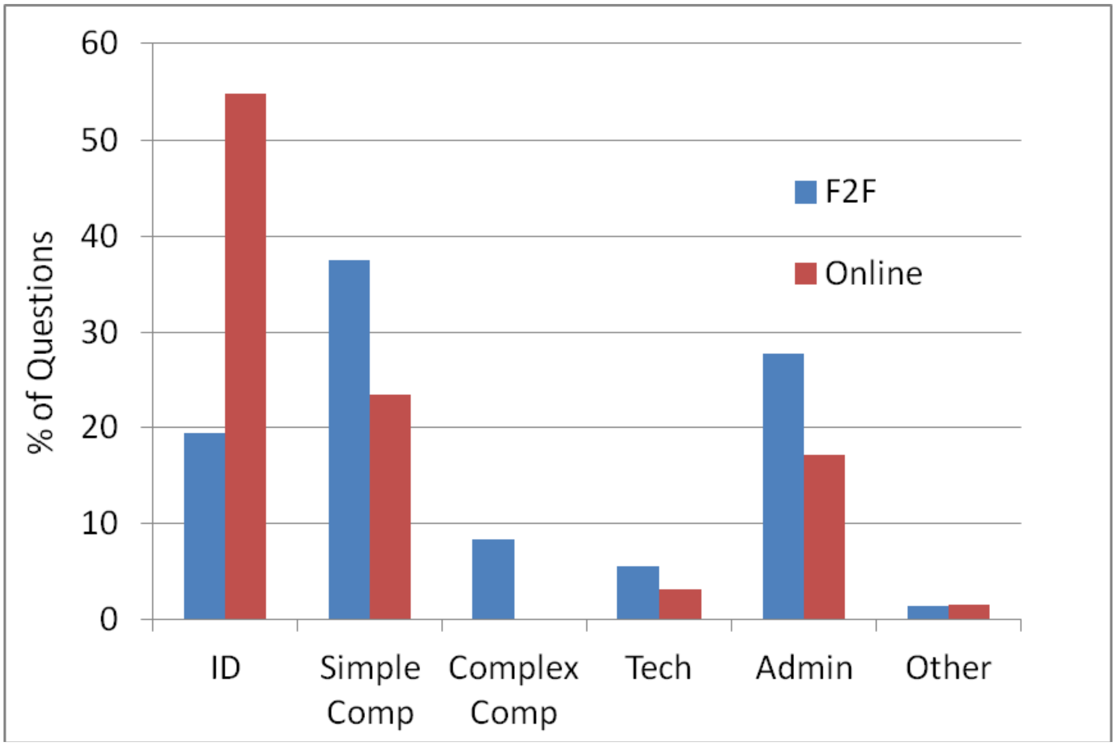

Figure 5.1: Classification of laboratory questions for F2F and online laboratories. Question categories are as follows: ID, identification; Simp Comp, simple comprehension; Complex Comp, complex comprehension; Tech, technical; Admin, administrative; Other, social or non-course related. Online students asked a greater number of identification questions compared to F2F students while F2F students asked more comprehension (both simple and complex) questions.

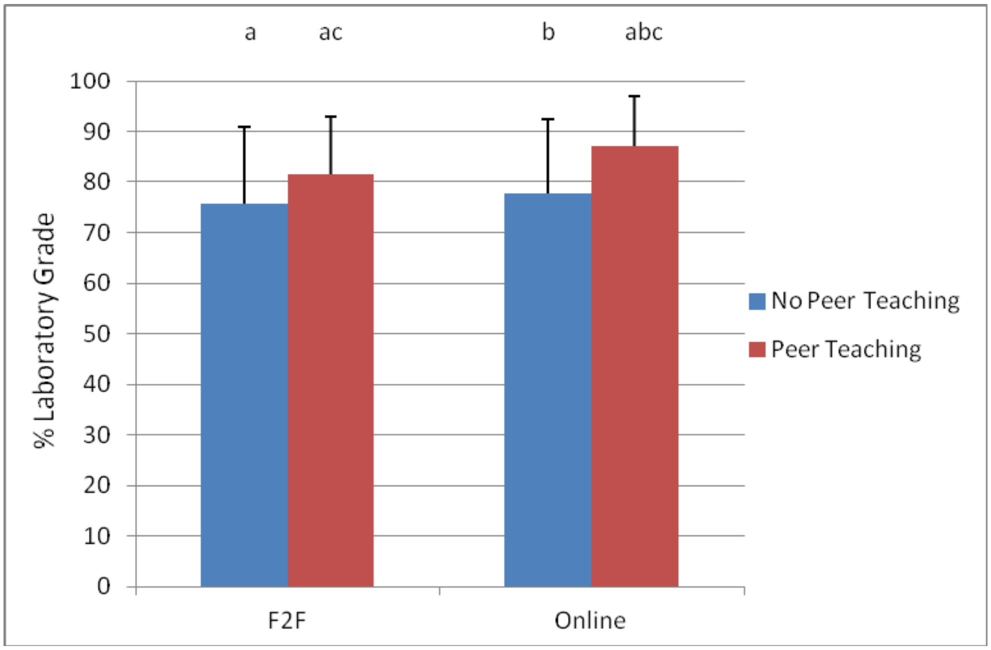

Figure 5.2: Final laboratory grade (mean% ± SD) for F2F and online laboratories with (2011) or without (2010) peer teaching intervention. There was a significant increase in laboratory grades for both F2F and online students with the inclusion of the peer teaching exercise. The impact of the peer teaching was greater for the online students with these students performing significantly better than the F2F students with peer teaching. Superscripts which are the same indicate significant differences ($p<0.05$).

Table 5.2: Peer Teaching Survey Results

	Face to Face N=137	**Online N=58**
Percentage of class responding to survey	57% (N=78)	14% (N=8)
Peer teaching participation 1=100% attendance, 2= approximately 75%, 3 = approximately 50%, 4 = approximately 25%, 5 = did not attend	1 = 26% 2= 17% 3 = 10% 4 = 23% 5 = 24%	1 = 12.5% 2 = 25% 3 = 0% 4 = 25% 5 = 37.5%
Did you find ATTENDING these sessions helped you learn the material? * 1= very helpful, 2=somewhat helpful, 3= not helpful	1= 20% 2 = 36% 3 = 44%	2= 100%
Did you find PRESENTING these slides helped you learn the material? * 1= very helpful, 2=somewhat helpful, 3= not helpful	1 = 15% 2 = 51% 3 = 34%	1 = 67% 2 = 33%
My group was more cohesive because of the peer teaching exercises.* 1= strongly agree, 2=somewhat agree, 3=somewhat disagree, 4=strongly disagree	1 = 2% 2 = 38% 3 = 28% 4 = 33%	1 = 0 % 2 = 50% 3 = 17% 4 = 33%
For the FIRST presentation this term, please indicate your comfort level preparing and giving	1 = 22%	1 = 0%

the presentation.* 1 = > normal level of stress for in-class presentation 2 = normal level of stress for in-class presentation 3 = < normal level of stress for in-class presentation	2 = 47% 3 = 31%	2 = 83% 3 = 17%
For the LAST presentation this term, please indicate your comfort level preparing and giving the presentation.* 1 = > normal level of stress for in-class presentation 2 = normal level of stress for in-class presentation 3 = < normal level of stress for in-class presentation	1 = 9% 2 = 41% 3 = 50%	1 = 0 % 2 = 17% 3 = 83%

***data from respondents who indicated that they had participated in peer teaching exercise**

remainder of the data was from survey respondents who indicated they participated in the peer teaching sessions. Two questions were designed to determine if students found attending or presenting during the peer teaching sessions beneficial. 100% of the online students found attending and presenting to be somewhat or very helpful while 56% of the F2F students found attending and 66% found presenting to be somewhat or very helpful. The statement “my group was more cohesive because of the peer teaching exercise” attempted to determine if the exercise influenced the group dynamic. 40% of the F2F and 50% of the online students indicated that the exercise lead to greater group cohesion. The final two questions examined the level of stress associated with presenting to their peers and if this stress subsided with experience. Results indicated that both online and F2F students did experience stress associated with the first peer teaching exercise, however, for the final exercise, the level of stress associated with the presentation had reduced.

The survey also contained two questions where students could provide feedback. They were first asked for any factors (positive or negative) which influenced their stress level for the presentation and the second was for any other feedback with respect to the peer teaching component of the laboratories. Common themes among the responses included:

- lack of interest because there were no grades assigned
- preference to use the time to complete the weekly assignment,
- decreased scheduling flexibility for the online students
- increased stress levels due to the short time to prepare presentations
- lack of stress because students were presenting to their peers and were able to get to know them better.

General feedback did indicate that despite their hesitation to participate, the students did find it a useful experience. One student ironically indicated that peer teaching was *“not effective as you must learn the material before you teach”* another indicated that *“it was helpful because I had to be master of the slide that I was in charge of*” and finally *“Having to prepare for the presentation and having to know the material right on, just in case someone asks a question about it [increased stress]. However, it did help me to learn”*.

5.4 Discussion

The purpose of this study was to measure student engagement in online and F2F histology courses through their interactions with the teaching assistants during the laboratory sessions. I also adapted an existing peer teaching exercise to the online laboratory environment in order to facilitate and subsequently evaluate learner–learner interactions. Moore (1989) has described interactions in distance education which can influence student's learning. Learner-instructor and learner–learner interactions have been examined in our study. Online learners may be susceptible to a reduction in these interactions due to their spatial and temporal distance from the instructor and each other (Sung and Mayer, 2012). This study has examined the learner–instructor interactions through student questions during the laboratory sessions and it has designed and evaluated an opportunity to increase learner–learner synchronous interactions with peer teaching.

5.4.1 Laboratory Questions

I was surprised to find a greater rate of questions from the online students compared to the F2F students. Our expectation was that there may be more questions from the F2F students because the teaching assistants were readily available as they circulated through the teaching laboratory. In contrast, the teaching assistant in the online course was available live online during the lab time or through email at other times, therefore separated spatially and possibly temporally from the student and not as readily available as the F2F teaching assistants would be. Despite this separation, the students did not appear to hesitate to ask for help when needed. Schoenfeld-Tacher et al (2001) conducted a similar study comparing the rates of questions from online chat sessions to F2F lectures. They also found that there was a greater rate of questions from the online chat sessions similarly suggesting that separation from the instructor did not impede student–instructor interactions. However, their study compares rates of questions from students in a lecture situation to a chat session where one would expect there would be a greater rate of questions during the chat sessions. Qualitative studies have shown that online students feel free to ask more questions and express themselves due to greater anonymity in online classrooms (Vonderwell, 2003). Transactional distance may be more of an impediment to student–instructor communication in the F2F classroom.

Our results showed that there were a greater percentage of Identification questions from the online students compared to the F2F students. These would be considered low cognitive level questions according to Bloom's taxonomy (Bloom et al., 1956). This finding could be due to the reduction in student–student interactions with the online students. Although not assessed, it has been observed that F2F students are physically surrounded by their peers and will discuss the slides throughout the laboratory session. Students may answer each other's more basic questions and reserve the more difficult questions for the instructor. The F2F students did have a greater percentage of Comprehension questions compared to Identification questions. The online students do not normally have the opportunity to discuss slides with their peers as the F2F students do and, therefore, may have to reserve these questions for the instructor. These results are in contrast to those found by Schoenfeld-Tacher et al (2001) who found that although the majority of questions from all groups were low level knowledge questions, the online students asked a greater proportion of higher level questions compared to the F2F lecture group. The laboratory exercises the online students completed in their study used microscope images captured at various powers while the online students in our study used virtual microscopy for their laboratory exercises. The use of the virtual microscope requires students to "read" the slide for ideal areas to examine more closely, similar to what would be required using a microscope (Cotter, 2001). The process of reading the slide leads to more identification questions as the students are not automatically presented with exemplars of the structures being studied as they were in the Schoenfeld-Tacher et al (2001) study. The F2F students in that study used microscopes which would be more similar to the laboratory exercises in our study. Those students also asked a higher proportion of lower level questions as would be expected.

Both online and F2F students asked few Technical questions. This assessment was conducted mid way through the course, at which point, there were very few technical problems that the students could not solve themselves. During the first week of the course, typically there are many Technical questions from both F2F and online students as they learn to use the classical microscope, virtual microscope and/or online classroom. There was also a similar level of Other or non-course related questions for both groups. It was expected that there would be a higher level of these more social questions in the F2F group as they are more familiar and comfortable with instructors and the laboratory sessions are a less formal environment. However, the online students showed similar levels of social interaction with the instructor through these questions. These results suggest that it is possible to have similar student–instructor interactions in online and F2F environments.

5.4.2 Peer Teaching

The introduction of peer teaching into the laboratory exercises attempted to accomplish two goals: increase student–student synchronous interaction in both the online and F2F environments and enhance learning in the histology laboratory. Peer teaching in F2F histology courses using virtual microscopy has been perceived to be beneficial for students through survey of both students and faculty (Plendl et al., 2009; Bloodgood, 2012; Shaw and Friedman, 2012) however, student outcomes remained unchanged (Bloodgood, 2012; Shaw and Friedman, 2012). I was able to show a significant increase in laboratory grades for the F2F (5.8%) and online students (9.4%) with the inclusion of the peer teaching exercises (Figure 5.2) with the online students showing a significant improvement over the F2F students as well. Students in the F2F laboratories were already engaged in informal discussions about the slides with their neighbours prior to the peer teaching exercise; however, the online students did not have the opportunity to do so. It is possible that the difference in improvement seen between the groups was due to the fact that some form of peer teaching was already occurring in the F2F class, while this was novel to the online students; therefore, the impact was more pronounced.

F2F students in our study were hesitant to participate in the peer teaching activity mainly due to their desire to finish the weekly assignment quickly, and due to the absence of a grade based motivation to participate. Just the same, our survey results show that 56% of F2F respondents found the presentations of other students somewhat or very helpful while 100% of online respondents found them somewhat helpful. This difference could again be due to the informal peer discussions that were already occurring in the F2F laboratory. In contrast, students in both groups found presenting to the other students either very helpful or somewhat helpful for learning the material, with 67% of online respondents reporting that it was very helpful for learning. Results indicating that the process of teaching in the peer teaching exercises is of the greatest benefit to learning has also been shown in gross anatomy and histology laboratories (Krych et al., 2005; Plendl et al., 2009).

I also surveyed students to determine if the peer teaching exercise enhanced group cohesion or promoted greater student–student interactions. With the low level of response rate for the online students I was not able to show meaningful differences between the groups for this measure.

Student comfort with the exercise was assessed by having students compare their stress level to that for other types of in class presentations from their other courses. Our results indicated that for both F2F and online students, the majority experienced either normal or greater than normal levels of stress for the first presentation. These results are understandable for the online students as they were required to learn the technical requirements of presenting online in addition to the presentation material itself. This learner–interface interaction has been described as a fourth type of interaction to consider in the online classroom (Hillman et al., 1994). Online students did have the opportunity to learn the virtual classroom technology and practice presentations prior to their first peer teaching session to overcome any learner–interface interaction difficulties. The F2F students were only required to learn how to navigate the virtual microscope which they may have already been using; however, these students were surrounded by their peers which for some may increase stress levels. The online students did communicate with each other in real time during these exercises; however, none of the students chose to use a web camera to show their faces during the presentation. For the final presentation, 50% of F2F and 83% of the online students reported feeling less than normal levels of stress associated with these presentations, indicating that they had become more comfortable with the process over the term and the technical aspects of the presentation were no longer a barrier. Student open ended feedback also supported the survey finding that students were comfortable with the exercises when they stated that presenting to their peers decreased the level of stress they felt.

5.4.3 Limitations

The presence of different laboratory instructors for the online and F2F laboratories could have had an impact on student outcomes. However, the instructors collaborated on all assessments to ensure they were similar in focus and difficulty levels.

A second limitation of the study was the reduced level of online student participation in the survey. Only 14% of the online students responded to the survey compared to 57% for the F2F students.

5.5 Conclusions

Despite initial hesitation to participate, I was able to show improved outcomes for online students involved in peer to peer teaching. The greatest learning benefit appears to result from students in the role of presenter as opposed to student in these exercises. Due to the low response rates, I was unable to show enhanced student-student interactions for the online students. In addition, the online students did not appear to hesitate to interact with the instructor as measured by their questions. These results suggest that the perceived limitations involving instructor and student communications in the online classroom may not be as much of a barrier as was once thought (Leasure et al., 2000).

5.6 Literature Cited

Allen IE, Seaman J. 2010. Learning on Demand: Online Education in the United States, 2009. In, 1st Ed. ed. Newburyport, MA: Babson Survey Research Group, Sloan Consortium, Inc. p 29.

Barak M, Rafaeli S. 2004. On-line question-posing and peer-assessment as means for web-based knowledge sharing in learning. Int J of Hum-Comp Stud 61:84-103.

Bloodgood R. 2012. Active learning: A small group histology laboratory exercise in a whole class setting utilizing virtual slides and peer education. Anat Sci Educ 5:367-373.

Bloom BS, Engelhart MD, Furst EJ, Hill WH, Krathwohl DR. 1956. Taxonomy of Educational Objectives: The Classification of Educational Goals by a Committee of College and University Examiners. New York: David McKay Company Inc.

Cotter JR. 2001. Laboratory instruction in histology at the University at Buffalo: Recent replacement of microscope exercises with computer applications. Anat Rec 265:212-221.

Evans DJR, Cuffe T. 2009. Near-peer teaching in anatomy: An approach for deeper learning. Anat Sci Educ 2:227-233.

Harper KA, Etkina E, Lin Y. 2003. Encouraging and analyzing student questions in a large physics course: meaningful patterns for instructors. J Res Sci Teach 40:776-791.

Hillman DCA, Willis DJ, Gunawardena CN. 1994. Learner - interface interaction in distance education: An extension of contemporary models and strategies for practitioners. Am J Dist Educ 8:30-42.

Krych AJ, March CN, Bryan RE, Peake BJ, Pawlina W, Carmichael SW. 2005. Reciprocal peer teaching: Students teaching students in the gross anatomy laboratory. Clin Anat 18:296-301.

Leasure AR, Davis L, Thievon SL. 2000. Comparison of student outcomes and preferences in a traditional vs. World Wide Web-based baccalaureate nursing research course. J Nurs Educ 39:149-154.

Moore M. 1989. Editorial: Three types of interaction. Am J Dist Educ 3:1-7.

Plendl J, Bahramsoltani M, Gemeinhardt O, Hünigen H, Käßmeyer S, Janczyk P. 2009. Active participation instead of passive behaviour opens up new vistas in education of veterinary anatomy and histology. Anat Histol Embryol 38:355-360.

Schoenfeld-Tacher R, McConnell S, Graham M. 2001. Do no harm - A comparison of the effects of on-line vs. traditional delivery media on a science course. J Sci Educ Tech 10:257-265.

Shaw PA, Friedman ES. 2012. Clinico-histologic conferences: Histology and disease. Anat Sci Educ 5:55-61.

Sung E, Mayer RE. 2012. Five facets of social presence in online distance education. Comput Hum Behav 28:1738-1747.

Vonderwell S. 2003. An examination of asynchronous communication experiences and perspectives of students in an online course: A case study. Internet High Educ 6:77-90.

Chapter 6

6 General Discussion

6.1 Online Education Trends

Enrolment in online distance education courses is outpacing that of post secondary education itself (Allen and Seaman, 2010). Recent statistics indicate that one in four post secondary students will take at least one online course in their education careers. As more online courses continue to be added to university calendars, it is important that these courses provide students with a high quality learning experience which would be equivalent to the face to face (F2F) version of the course. While there are many online distance education course options for social science and arts students, there are fewer options for the science student (Shachar and Neumann, 2010). This dissertation provides an assessment of a histology laboratory course which is offered entirely in the online format. This same course has successfully been offered in the traditional F2F format at our institution for over 40 years.

The introduction of virtual microscopy to histology teaching has transformed how students learn histology (Bloodgood and Ogilvie, 2006; Drake et al., 2009). The loss of traditional microscopy skills with the introduction of this technology has introduced a new skill set, that of virtual microscopy skills (Coleman, 2009). Virtual microscopy lends itself perfectly to the online format and has enabled the creation of this fully online histology course which includes a laboratory component.

6.2 Transactional Distance

The concept of transactional distance in distance education has been introduced and refined by Moore (1973; 1989; 1990) to describe the interactions which occur in the distance education classroom. Although Moore states that these distances are also present in the F2F classroom (Moore, 1990), teaching and learning in the distance education classroom are "better understood not as an aberration from the classroom, but as a significantly different pedagogical domain" (Moore, 2007). The learner in a distance education classroom has greater autonomy than their counterpart in the F2F classroom. This autonomy increases as the transactional distance increases (Saba, 1988).

The interactions described by Moore (1989) as crucial to student success in the distance education classroom are: learner–content, which describes the process of "intellectually interacting with content" to produce changes in the student's knowledge; learner–instructor, where the instructor has selected and refined the content and its presentation and also provides motivation and feedback to the student. This interaction is considered to be the most important by educators and highly desired by students. The third interaction described by Moore is that of learner–learner. This interaction occurs between peers with or without the presence of the instructor and has also been considered a valuable source of learning. Currently, most distance education courses take the form of an online course. This has introduced a fourth type of interaction, that of the learner–interface (Hillman et al., 1994). The learner–interface interaction is significant in this type of course as all of the other interactions take place through the use of online technology and students (and instructors) must be proficient in this area in order to access the course (Flowers et al., 2012). This dissertation evaluates the online histology course in the context of these interactions.

6.2.1 Learner–Content Interactions

The learner–content interaction has been assessed in Chapters 3 and 4. Chapter 3 examined student outcomes for the online histology course in comparison to the F2F course. The results from that analysis examined outcomes from both the laboratory and lecture components of the course and indicated that performance for the online students was not significantly different than that for the F2F students (Figure 3.4). Significant positive correlations between student's previous performance in foundational science courses (FCA) and their overall course grade in Histology indicated that the FCAs were a predictor of performance in Histology for both online and F2F students (Figure 3.5). It was important to ensure that students with lower previous grades (FCA) were not disadvantaged by the course format which was determined by grouping students according to their previous grades (Table 3.2) and calculating final course grade means for each of these groups. It was found that there were no significant differences between their previous grade and the final course grade for any of the groups. These results indicated that all groups of students performed as their previous grades would have predicted. These results show that the transactional distance measured by the student–content interaction was not an impediment for the online students.

Student attendance can also be considered as an indicator of learner–content interaction. Results showed that the online students had greater overall lecture attendance (Figure 4.1) which assumes they spent more time interacting with the course content and therefore, potentially greater outcome results. The results from this study also showed that lecture attendance has a direct relationship with exam performance as measured by the exam question index score (EQIS), which showed a significant improvement in performance on individual exam questions based on lectures attended (Figure 4.5). The surprising result from this study was that online students, who had the opportunity to view archives of all lectures multiple times, did not have a significantly improved EQIS if the archives were viewed more than once. Therefore, initial interaction with the course content does have an impact on exam performance; however, repeated interaction in the same manner (re-watching lecture archive) does not. These results suggest that interaction with the course content beyond the initial lecture exposure using other methods, for example textbook readings, may be more beneficial.

Finally, results from Chapter 4 indicated that lecture attendance had an impact on course performance and that the online class had significantly higher attendance compared to the F2F group. From these results, one would assume that they then would also have improved course outcomes; however, the outcomes for these groups were not significantly different despite having different attendance levels. This suggests that there still remains some transactional distance with respect to the learner–content interaction in the online version of the course.

6.2.2 Learner–Instructor Interactions

The student – instructor interactions were assessed using the laboratory questions study in Chapter 5. Results from this study indicated that online students were more likely to ask questions of the instructor compared to the F2F students. However, according to Bloom's Taxonomy (1956), the majority of the questions were low level and thus could be answered quickly by the instructor (Figure 5.1). These results suggest that the students were very comfortable approaching the instructor and thus the transactional distance was actually greater for F2F than online modes of delivery.

Interestingly, results from Chapter 4 examining student attendance suggest that although the transactional distance has diminished, this distance still exists; however, it exists by the student's choice. Students were able to attend lectures synchronously, in real time and ask questions of the instructor in real time, however, after the initial lectures very few students attended lectures live with most choosing to attend asynchronously through the use of archives (Figure 4.2). These students appeared to be willing to sacrifice immediate interaction with the instructor in favour of control over the pace of the lecture. Therefore, while technology allowed for a major reduction of the transactional distance between the student and instructor, students choose to maintain some distance and autonomy through their preference for the use of archived lectures over live lectures.

6.2.3 Learner–Learner Interactions

Attempts to increase online learner–learner interactions were done through the synchronous peer teaching exercise described in Chapter 5. This type of interaction is often overlooked in distance education; however, studies have shown that it can be valuable method of learning. This teaching technique has been successfully used in F2F anatomy courses (Krych et al., 2005; Bloodgood, 2012). Results from Chapter 5 showed that laboratory outcomes in both F2F and online courses were improved with the addition of the peer teaching exercise compared to the previous year without peer teaching. Student feedback from surveys also indicated that this exercise improved their ability to learn the material through the process of teaching the other students. In contrast, this exercise had less impact on the F2F students, possibly because these students were already working together informally during the laboratory sessions and the peer teaching did not increase their level of interactions. Students in both F2F and online courses did have the opportunity to interact with each other through discussion boards; however, these interactions would have been asynchronous. The peer teaching was an attempt to introduce synchronous interactions between the online students. Based on our promising results, more attention should be given to increasing this type of interaction in the online classroom.

6.2.4 Learner–Interface Interactions

The influence of learner–interface interactions on student performance were not directly assessed in any of the studies conducted. This interaction involves the student's ability to manipulate the technology used to deliver the course content. Any problems with this interaction were identified and resolved usually during the first week of the course. An examination of attendance patterns showed initially high attendance levels (Figure 4.2) as well as high repeat archive use (Figure 4.3a). As the course progressed, the synchronous attendance declined and archive use increased (Figure 4.2), however, repeat archive use declined (Figure 4.3a). This pattern suggests that students learned how to use the virtual classroom to their advantage, preferring the archives which allowed pause and rewind features; thus tailoring the online classroom to their needs. As they became familiar with the technology, they relied less on repeat archive use, thus making more efficient use of their study time.

An additional indicator of the learner–interface interaction was seen through the analysis of the questions during the laboratory sessions (Figure 5.1), where very few of the questions asked were technical in their content. This assessment was conducted mid-way through the course where any technical issues would have already been resolved. However, it does demonstrate that the students were able to master the learner–interface interaction.

The peer teaching exercise described in Chapter 5 allowed the students to learn how to take on the role of instructor in the virtual classroom. In order to reduce stress associated with technical aspects of an online presentation, they were given the opportunity to familiarize themselves with the teaching tools prior to their lesson. Despite this training, survey results from that exercise showed that student comfort level between the first and last peer teaching sessions improved significantly, suggesting an initial anxiety level associated with new technology (Table 5.2). It is important for instructors to recognize the importance of this interaction and if assessments are conducted using technology, trial assessments, which are not graded, should be created to identify and eliminate any technological barriers and reduce student anxiety.

6.3 Summary of Contributions to Educational Literature

In Chapter 3 I have shown that the online format is an effective method of delivering histology lecture and laboratory content using synchronous videoconferencing software and virtual microscopy software. I have also shown that previous grades are a predictor of performance in an online course as it is in the case of a F2F mode of delivery. In Chapter 4 I showed that, through the use of archived lectures, online attendance is greater than that for the same F2F course. I have also shown that online and F2F attendance has an impact on course performance; however, repeated archive viewing online does not lead to improvements in examination grades. In Chapter 5 I have shown that, during laboratory sessions, students ask proportionally more low cognitive level questions possibly due to the use of the virtual microscope and isolation from their peers. I have also shown that synchronous peer teaching is an effective method to enhance histology learning in an online environment and that students perceive the process of teaching others to be more effective than learning from others.

6.4 General Summary

The transactional distance in online education has diminished but has not been eliminated. One indicator that the transactional distance still exists in the online classroom was the response rates for the instructor evaluation (6.3%; Table 3.3) and peer teaching survey (14%; Table 5.2). These response rates were dramatically lower compared to the F2F students (instructor evaluation 93.1% and peer teaching survey 57%). The low response rates displayed by the online students can be seen as an indicator of lower student engagement compared to the F2F students.

I have shown that the transactional distance in the online classroom with respect to the learner–content interactions has diminished compared to when these distances were first described; however, student attendance data suggested with significantly greater attendance levels, online students should outperform their F2F counterparts. The learner–instructor interaction distance has also diminished through improvements in technology; students are able to communicate with their instructor synchronously or asynchronously using numerous communication methods. The anonymity of the online classroom may reduce the transactional distance to less than that seen in the F2F classrooms, especially large classes where F2F students are hesitant to participate.

Teaching methods designed to increase interactions among students, such as the peer teaching exercise, can foster an online community and potentially improve student outcomes. However, these synchronous exercises reduced the flexibility and autonomy some distance education students desired. Course design and teaching methods should continue to be developed and tested to reduce these distances yet still allow distance students some of the autonomy they are seeking.

6.5 Limitations

Limitations to this study can be found. First, because this study was conducted on a course where grades were important to the future of the students enrolled, I was limited by the interventions I could introduce. Ideally, students would be assigned into either the

F2F or online format based on randomized previous grades and the two groups would cross over to experience the other format. This would have allowed the students to give feedback on their preferences. Due to ethical considerations, students had to be able to self select the version of the course they would enrol in and technical limitations did not allow for the cross over experimental design. However, previous grades were used to ensure the integrity of the data and account for the lack of randomization.

The second limitation to the study was the lack of participation with the online students. As previously mentioned, participation in the peer teaching survey and institutional instructor evaluations were very low for this group which made it difficult to draw conclusions from the data. Response rates to these surveys can, in of itself, be considered important results as they can be seen as an indicator of student engagement.

6.6 Future Directions

Based on these results and the results of others (see for example Shachar and Neumann (2010)), the straightforward comparison of online and F2F courses has confirmed that online instruction, even with a laboratory component, can be as effective as F2F instruction. The focus of future research in this area should include specific methods for increasing student engagement in online education. With such high levels of student attendance in the online classroom, teaching methods must be employed and tested to increase the engagement of these students as there is the potential for these students to outperform their F2F counterparts. Methods must be developed and tested which facilitate an increase in meaningful interactions in all areas: student–student, student-instructor and student-content.

In addition, further investigations should focus on successful elements of online instruction and how those elements might be used to improve F2F courses. For example, blended learning, where options exist for both online and F2F interactions allowing greater student autonomy yet still maintaining close student–instructor and student–student interactions may provide the optimal balance.

6.7 Literature Cited

Allen IE, Seaman J. 2010. Learning on Demand: Online Education in the United States, 2009. In, 1st Ed. ed. Newburyport, MA: Babson Survey Research Group, Sloan Consortium, Inc. p 29.

Bloodgood R. 2012. Active learning: A small group histology laboratory exercise in a whole class setting utilizing virtual slides and peer education. Anat Sci Educ 5:367-373.

Bloodgood RA, Ogilvie RW. 2006. Trends in histology laboratory teaching in United States medical schools. Anat Rec 289B:169-175.

Bloom BS, Engelhart MD, Furst EJ, Hill WH, Krathwohl DR. 1956. Taxonomy of Educational Objectives: The Classification of Educational Goals by a Committee of College and University Examiners. New York: David McKay Company Inc.

Coleman R. 2009. Can histology and pathology be taught without microscopes? The advantages and disavantages of virtual histology. Acta Histochem 111:1-4.

Drake RL, McBride JM, Lachman N, Pawlina W. 2009. Medical education in the anatomical sciences: the winds of change continue to blow. Anat Sci Educ 2:253-259.

Flowers L, White E, Raynor J. 2012. Examining the transactional distance theory in a web-enhanced biology course. J Stud Educ 2:144 - 154.

Hillman DCA, Willis DJ, Gunawardena CN. 1994. Learner - interface interaction in distance education: An extension of contemporary models and strategies for practitioners. Am J Dist Educ 8:30-42.

Krych AJ, March CN, Bryan RE, Peake BJ, Pawlina W, Carmichael SW. 2005. Reciprocal peer teaching: Students teaching students in the gross anatomy laboratory. Clin Anat 18:296-301.

Moore M. 1989. Editorial: Three types of interaction. Am J Dist Educ 3:1-7.

Moore M. 1990. Recent contributions to the theory of distance education. Open Learning: The Journal of Open, Distance and e-Learning 5:10-15.

Moore M. 2007. The Theory of Transactional Distance. In: Moore M, editor. Handbook of Distance Education, 2nd ed. Mahwah, NJ: Lawrence Erlbaum Associates Inc. p 89-105.

Moore MG. 1973. Toward a Theory of Independent Learning and Teaching. The Journal of Higher Education 44:661-679.

Saba F. 1988. Concepts: Integrated telecommunications systems and instructional transation. Am J Dist Educ 2:17 - 24

Shachar M, Neumann Y. 2010. Twenty years of research on the academic performance differences between traditional and distance learning: Summative meta-analysis and trend examination. MERLOT J Online Learn Teach 6:318 - 334.

Appendices

Appendix A: Ethics Documentation

Office of Research Ethics

The University of Western Ontario

Website: www.uwo.ca/research/ethics

Use of Human Subjects - Ethics Approval Notice

Western

Principal Investigator: Dr. K. Rogers

Review Number: 17426E | **Review Level:** Expedited

Review Date: September 15, 2010 | **Approved Local # of Participants:** 360

Protocol Title: The Evaluation of an Online Microscopic Anatomy Course

Department and Institution: Anatomy, University of Western Ontario

Sponsor:

Ethics Approval Date: January 28, 2011 | **Expiry Date:** July 31, 2011

Documents Reviewed and Approved: UWO Protocol. Announcement. Class Email. Poster. Letter of Information and Consent (Current), Letter of Information and Consent (Former).

Documents Received for Information:

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced study on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the HSREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of monitor, telephone number). Expedited review of minor change(s) in ongoing studies will be considered. Subjects must receive a copy of the signed information/consent documentation.

Investigators must promptly also report to the HSREB:

a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to this office for approval.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

Chair of HSREB: Dr. Joseph Gilbert
FDA Ref. #: IRB 00000940

Ethics Officer to Contact for Further Information		
☐ Janice Sutherland	☐ Elizabeth Wambolt	☑ Grace Kelly

This is an official document. Please retain the original in your files.

cc: ORE File

UWO HSREB Ethics Approval - Initial
V.2008-07-01 (rptApprovalNoticeHSREB_Initial)

17426E

Page 1 of 1

Research Western

Use of Human Participants - Ethics Approval Notice

Principal Investigator: Dr. Kem Rogers
Review Number: 17426E
Review Level: Delegated
Approved Local Adult Participants: 360
Approved Local Minor Participants: 0
Protocol Title: The Evaluation of an Online Microscopic Anatomy Course
Department & Institution: Anatomy & Cell Biology,
Sponsor:
Ethics Approval Date: December 22, 2011 **Expiry Date:** April 30, 2012
Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
Revised UWO Protocol	A question tracking sheet will be used by the Teaching Assistants during the lab sessions.	
Other	Tracking Sheet	

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

The Chair of the HSREB is Dr. Joseph Gilbert. The UWO HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Ethics Officer to Contact for Further Information

Janice Sutherland	Grace Kelly	Shantel Walcott

This is an official document. Please retain the original in your files.

The **University** *of* **Western Ontario**
Office of Research Ethics

Research Western

Use of Human Participants - Ethics Approval Notice

Principal Investigator: Dr. Kem Rogers
Review Number: 17426E
Review Level: Delegated
Approved Local Adult Participants: 360
Approved Local Minor Participants: 0
Protocol Title: The Evaluation of an Online Microscopic Anatomy Course
Department & Institution: Anatomy & Cell Biology,
Sponsor:
Ethics Approval Date: July 28, 2011 **Expiry Date:** April 30, 2012
Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
Revised Study End Date	The study end date has been revised to April 30, 2012 to allow for project completion.	

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the *membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.*

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

The Chair of the HSREB is Dr. Joseph Gilbert. The UWO HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Ethics Officer to Contact for Further Information

☐ Janice Sutherland	☑ Grace Kelly	☐ Shantel Walcott

This is an official document. Please retain the original in your files.

***The* University *of* Western Ontario**
Office of Research Ethics

Research Western

Use of Human Participants - Ethics Approval Notice

Principal Investigator: Dr. Kem Rogers
Review Number: 17426E
Review Level: Delegated
Approved Local Adult Participants: 360
Approved Local Minor Participants: 0
Protocol Title: The Evaluation of an Online Microscopic Anatomy Course
Department & Institution: Anatomy & Cell Biology,
Sponsor:
Ethics Approval Date: September 15, 2011 **Expiry Date:** April 30, 2012
Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
Revised UWO Protocol	The study end date was previously revised in order to accommodate the current summer course concluding in August 2011. The students have been invited to participate in the approved study which asks them to complete questionnaires at the completion of the course and a quiz at 6 months out. A peer teaching survey has now been included as well.	
Other	Announcement / Email	
Other	Instrument - Peer Teaching Survey	
Revised Letter of Information & Consent		

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

The Chair of the HSREB is Dr. Joseph Gilbert. The UWO HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Ethics Officer to Contact for Further Information

Janice Sutherland	✓ Grace Kelly	Shantel Walcott

The **University** *of* **Western Ontario**
Office of Research Ethics

Research Western

Use of Human Participants - Ethics Approval Notice

Principal Investigator: Dr. Kem Rogers
Review Number:17426E
Review Level: Delegated
Approved Local Adult Participants:360
Approved Local Minor Participants:0
Protocol Title: The Evaluation of an Online Microscopic Anatomy Course
Department & Institution: Schulich School of Medicine and Dentistry\Anatomy & Cell Biology,
Sponsor:
Ethics Approval Date: April 05, 2012 **Expiry Date:**April 30, 2012
Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
Revised Western University Protocol	An additional group of subjects have been added to the study. In addition, anonymous course grades will be collected to compare.	
Letter of Information	Revised	
Advertisement	Email	

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the University of Western Ontario Updated Approval Request Form.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

The Chair of the HSREB is Dr. Joseph Gilbert. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Ethics Officer to Contact for Further Information

Janice Sutherland	✓Grace Kelly	Shantel Walcott

This is an official document. Please retain the original in your files.

The University *of* Western Ontario
Office of Research Ethics

Appendix B: Peer Teaching Survey

1. Please indicate the format of the course you were enrolled in.
   - ☐ Online ☐ Face to Face

2. What percentage of your classmate's presentations did you attend/watch this term?
   - ☐ 100%
   - ☐ Approximately 75%
   - ☐ Approximately 50%
   - ☐ Approximately 25%
   - ☐ Did not attend any other presentations

3. Did you find ATTENDING these sessions helped you learn the material?
   - ☐ Very helpful
   - ☐ Somewhat helpful
   - ☐ Not helpful

4. Did you find PRESENTING the slides helped you learn the material?
   - ☐ Very helpful
   - ☐ Somewhat helpful
   - ☐ Not helpful

5. My group was more cohesive because of the peer teaching exercises
   - ☐ Strongly agree: We worked well together and got to know each other
   - ☐ Somewhat agree: Some positive group cohesion
   - ☐ Somewhat disagree: No positive group cohesion but completed what was required
   - ☐ Strongly disagree: No group cohesion. We did not work as a group.

6. For the FIRST presentation this term, please indicate your comfort level preparing and giving the presentation.
   - ☐ Greater than normal level of stress for an in-class presentation
   - ☐ Normal level of stress for an in-class presentation
   - ☐ Less than normal level of stress for an in-class presentation

7. For the LAST presentation this term, please indicate your comfort level preparing and giving the presentation.
   - ☐ Greater than normal level of stress for an in-class presentation
   - ☐ Normal level of stress for an in-class presentation
   - ☐ Less than normal level of stress for an in-class presentation

8. Can you identify any factors which influenced – both positive and/or negative – your stress level for the presentations.

9. Please provide any other feedback with respect to the peer teaching component of the labs.

Curriculum Vitae

Name:	Michele Barbeau
Post-secondary Education and Degrees:	University of Western Ontario London, Ontario, Canada 1984-1988 B.Sc. Cell Biology
	The University of Western Ontario London, Ontario, Canada 1989-1991 B.Sc. Nutrition
	The University of Western Ontario London, Ontario, Canada 1991-1995 M.Sc. Anatomy
	The University of Western Ontario London, Ontario, Canada 1995-1996 B.Ed.
	The University of Western Ontario London, Ontario, Canada 2008-2012 Ph.D. Candidate
Honours and Awards:	American Association of Anatomists (AAA) Educational Research Platform Award Finalist 2012
	Gabriel G. Altmann Research Award – Clinical Department of Anatomy and Cell Biology Research Day 2011
	Social Science and Humanities Research Council (SSHRC) Doctoral Fellowship 2011-2012
	Ontario Graduate Scholarship in Science and Technology (OGSST) 2010-2011
	Western Graduate Research Scholarships (WGRS) 2008-2012

	Schulich Graduate Scholarship 2008-2011
	Special University Scholarship 1991-1993
	Sister St. Michael Memorial Scholarship 1990
Related Work Experience	Teaching Assistant – Gross Anatomy, Histology The University of Western Ontario 2009-2012, 1992- 1994
	Adjunct Professor – Histology The University of Western Ontario 2006-2010
	Lecturer – Histology The University of Western Ontario 2000 - 2006

Publications:

Barbeau, M.L., Johnson, M., Gibson, C., Rogers, K.A. 2012. The development and assessment of an online microscopic anatomy laboratory course. Anatomical Sciences Education (accepted with revisions)

Barbeau, M.L. and Rogers, K.A. 2012. Do lectures matter? An assessment of student attendance in an online histology course (manuscript in preparation)

Barbeau, M.L. and Rogers, K.A. 2012. Increasing student-student online interactions: An evaluation of a peer teaching exercise in an online histology course. (manuscript in preparation)

Barbeau, M.L., Whitman, S.C. and Rogers, K.A. 1995. Probucol, but not MaxEPA fish oil, inhibits mononuclear cell adhesion to the aortic intima in the rat model of atherosclerosis. Biochemistry and Cell Biology 73: 283-288.

Barbeau, M.L., Klemp, K.L., Guyton, J.R., and Rogers, K.A. 1997. Dietary fish oil: influence on lesion regression in the porcine model of atherosclerosis. Arteriosclerosis Thrombosis and Vascular Biology 17: 688-694.