ASSESSMENT OF THE EFFICACY OF BLENDED LEARNING IN AN INTRODUCTORY PHARMACY CLASS

By

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A Dissertation submitted to the graduate degree program in Chemistry and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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AN INTRODUCTORY PHARMACY CLASS

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Abstract

Christina Elizabeth Munson

University of Kansas, April 2010

Blended learning is the convergence between traditional face-to-face learning typically seen in a university setting and a computer-mediated learning environment, and is increasingly being seen as a viable alternative for learning instruction.

Pharmaceutical calculations (PC) is a course taken by students in the first year in the school of pharmacy at the University of Kansas (KU SOP). One of the objectives of the PC class is that students are able to perform calculations with minimal error consistently. This requires repetitive drill which is a poor use of class time. By moving presentation of material online and using class time for small learning group problem solving as well as practice exams, the transformation of the course to a blended or hybrid course is assessed for efficacy and found to have student outcomes which are comparable to previous face-to-face (F2F) classes. As KU SOP expands it class sizes from 105 to ~150 students and its campuses (building a satellite campus in Wichita, Kansas), being able to provide quality instruction at a reasonable cost is desirable. By redesigning PC to be a hybrid course, the need to hire additional instructors and/or increase available resources is minimized. Instructors remain for the large part on the main campus in Lawrence while students are learning at remote locations, a cost-effective measure for all parties involved.

Using small learning groups (consisting of not more than 3 or 4 students) to work problems in PC was demonstrated to be an effective use of F2F class time in the fall semester, 2008 at KU. The class was taught by the same instructor in the fall of 2009 using blended

learning as the class format. The current computer Learning Management System (LMS) in use at KU is Blackboard(©2010). By using Blackboard to deliver lectures and have students work through tutorials to learn the material, class time was devoted to highly-focused problem solving. Due to unequal data distribution, the non-parametric tests Kruskal-Wallis and Mann-Whitney were used to assess student outcomes from three different classes (years) of students. The only significant differences were between groups of males in two different face-to-face classes. There was no significant difference between BL and F2F class formats. In general, blended learning was found to be as effective as a traditional F2F class format when comparing final student outcomes.

Dedication

To my mother Joan Elizabeth Huber

Acknowledgements

It truly takes a village to get your Ph.D. at the age of 42, with 3 children, several pets, a live-in mother and a professor husband who travels several weeks out of the year. My village is large and vast.

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I can’t thank my best friend and husband Eric enough for his love and devotion. It sure wasn’t easy but here we are. Can you not throw me anymore curveballs?

Finally, thanks to God for the blessings you have given me. I hope I show my appreciation by paying it forward.

Rock Chalk Jayhawk!

Go Big Blue!

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Chapter 1

Introduction

Section 1.1 Background

According to the 2007 Trends in International Mathematics and Science Study released on December 9, 2008, the United States is not on the list of top-10 science and math education countries (National Center for EducationStatistics 2007). Long-term economic development in any country depends on the competencies of its work force. Educating today's youth in science and technology is crucial and has never been more important as competition for jobs in today's work force becomes tighter.

The National Research Council (NRC) reported in *How People Learn* that research in education over the last two decades suggests that learning occurs best during a process of inquiry, followed by metacognitive reflection (Department of Education 2000). In other words, learning occurs most effectively when it is an active, dynamic process, rather than a passive end-product.

Researchers in science education in the United States studying strategies for improving course offerings have two clear directives. First, retaining students in STEM (Science, Technology, Engineering, Math) disciplines is crucial. Second, understanding how students learn best can be thought of as the missing key in retaining those students.

One career pathway involving science training is pharmacy. More and more students with an interest in math and science are gravitating towards a degree in pharmacy as the need for well-trained health care professionals is increasing as a record number of baby boomers enter retirement in the 21st century.

Pharmacy education in America has undergone a major transformation over the past two decades with the adoption of the doctor of pharmacy (PharmD) degree as the only professional degree offered. Concurrent with this transformation has been a revision of the Standards and

Guidelines for the PharmD degree program. These revisions are designed to assist colleges and schools of pharmacy in developing and maintaining academically strong, effective programs currently in demand by today's health care consumers.

Since its founding in 1885, the school of pharmacy at the University of Kansas (KU SOP) has been a leader in pharmaceutical education. Since 1996, the school has offered only the doctor of pharmacy degree as the entry level practice degree. The curriculum has been significantly revised to provide the education and experiential training that will provide the student with the knowledge, skills, and abilities required of the pharmacy practitioner in the 21st century. The curriculum is comprehensive in scope, based on the strict accreditation standards set forth by the Accreditation Council for Pharmacy Education (Standards 2007) and is designed to produce a highly competent general practitioner.

KU SOP continues to progress through the construction of a new facility in Lawrence, Kansas. The new pharmacy education building, scheduled to open in the fall of 2010, will expand the program significantly. According to the Dean of the School of Pharmacy, Ken Audus, "The building will also serve our [pharmacy] program's mission of educating researchers in drug discovery, design and development. Currently, we have online graduate courses broadcast into major pharmaceutical companies and to India. The distance education technology in the new building will permit outreach for professional, graduate, and continuing education within Kansas and across the United States and the world". (KU website: www.pharmacy.ku.edu, accessed June 27th, 2009).

Pharmacy education in the United States is undergoing a renaissance as schools undergo strategic planning processes to keep up with demand for pharmacists in the United States by increasing enrollment, and to attract the best and brightest students into the profession. In the

traditional classroom setting in U.S. pharmacy schools, communication, retention, and repetition of factual information is the status quo (Blouin, Joyner, and Pollack 2008). The use of class time to work on transmitting basic, factual content limits the ability of the instructor to explore concepts in depth, engage students at a higher intellectual level, or work on problem solving or critical thinking skills. Frustration with the pedagogical status quo is high for all stakeholders. Sitting in a classroom listening to a traditional, content-rich lecture is viewed by students as a poor use of time. Faculty are frustrated because they wish to engage students at a higher level of learning than is associated with the transmission of factual information (Blouin 2009). The administration is frustrated because the universities most valuable resource, its faculty, must devote much of their time to the dissemination of factual information with limited opportunities to utilize that intellectual resource to improve didactic education. As schools struggle with the question of how to improve learning in pharmacy education, the research into learning points to more novel ways to meet the goals of the student, faculty and administration.

The traditional model of teaching and learning in a university setting involves student and professor showing up at the same time in a designated classroom. This is a face-to-face (F2F) meeting environment. The professor proceeds to lecture, and the student takes notes. In this long-held communication model, learning is presumed to be taking place. Research in learning theories has shown that this model is one of the least effective means of transferring information (Fink 2003). "Teaching" is what the instructor thinks of himself/herself as doing in a F2F classroom. Whether or not learning is taking place depends on several factors. The teaching-learning connection is the intersection of an instructor's teaching activities and the learning needs of the students – the classroom environment. As colleges and universities seek to improve teaching, the focus has evolved to become about improving learning. This shift is described by

Barr and Tagg (1995) as a change from the "instructor paradigm" to the "learning paradigm" (Figure 1-1). The *Instruction Paradigm* defines learning as a passive event – students are fed information by the instructor. The *Learning Paradigm* forces students to be active discoverers and constructors of their own knowledge and reality. Colleges and universities in this learning paradigm no longer offer courses and programs, but instead are the hotbed of creative and powerful learning environments. Lecturers become the designers of learning environments.

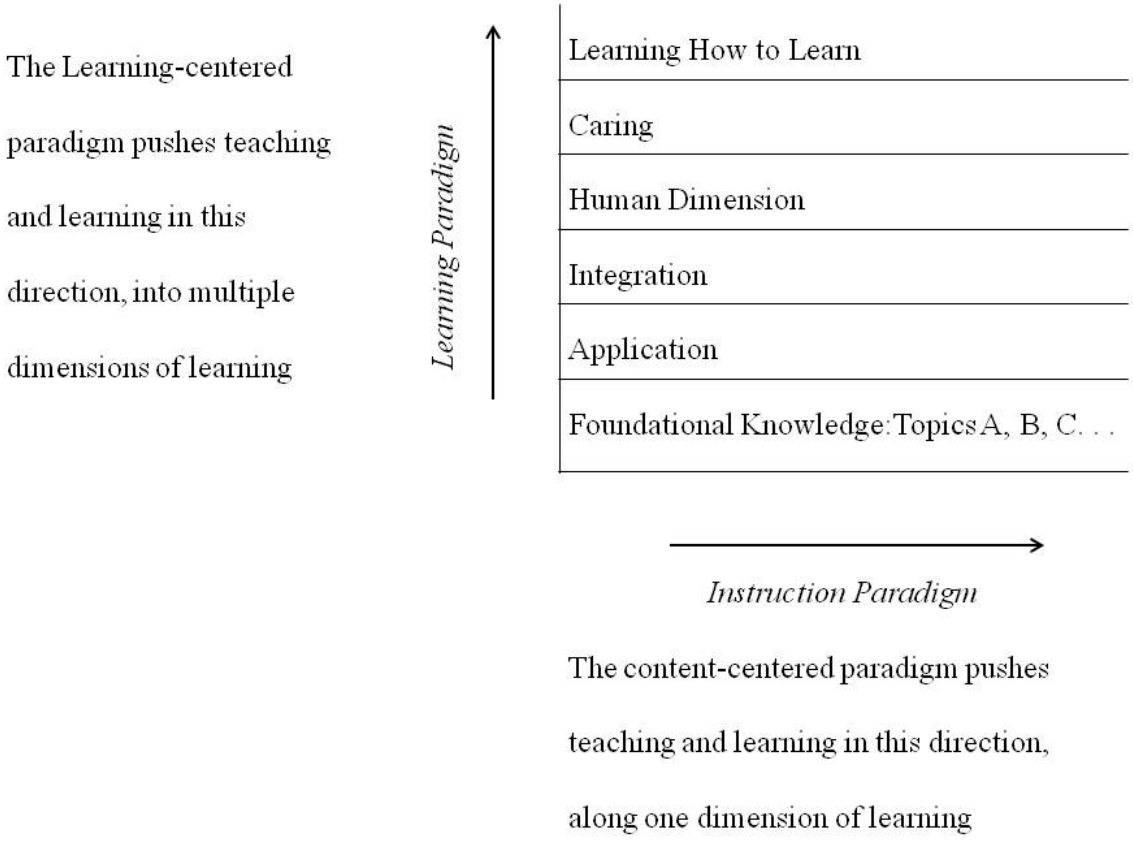

Figure 1-1: The Effects of Two Different Paradigms (Fink 2003)

Reevaluating what goes on in a classroom has also forced educators to evaluate where learning should take place. Although computers have been used to aid instruction in education

for several decades, offering higher-education classes exclusively online is a relatively new phenomenon in higher education (Allen and Seaman 2005, 2007). As learners have become more diverse in age and life experience, colleges and universities realized that the one-size-fits-all mode of face-to-face instruction and course offerings was not meeting the needs of today's learners. The advent of web-based learning has allowed many of today's learners to get an education which would otherwise be impossible due to family obligations. The benefits of online learning have far reaching economic impact for many students – particularly first-generation college students and non-traditional students, for whom access to college classes in the past was not available (Allen and Seaman 2007).

Despite the perceived value of online instruction, it is not a panacea. The social connection that students seek may not be obvious on an online environment. Many researchers in learning theories feel that learning takes place most effectively in a collaborative learning environment – typically a face-to-face environment. Education experts believe that learning should be an active rather than a passive process. Social constructivism theory describes a way of knowing in which students or learners construct their new understanding and knowledge during the process of social interaction with others (Wink and Putney 2002; Hirst 1983; Kim 2008). Lev Vgotsky, a Russian psychologist born in 1896, wrote extensively about constructivist learning models in the early twentieth century. Vgotsky's writings span 6 volumes, written over roughly 10 years, from his Psychology of Art (1925) to Thought and Language [or Thinking and Speech] (1934). Vgotsky, the main architect of social constructivism, stated that by interaction and help from more knowledgable peers, one could develop more profound comprehension than his/her individual capacity. The Zone of Proximal Development (Vgotsky, 1978; Harland, 2003; Palincsar, 1998) can best be understood as a bridge between knowledge that a learner cannot

learn on his/her own, but can learn with the assistance and guidance of a teacher or other learners (Figure 1-2).

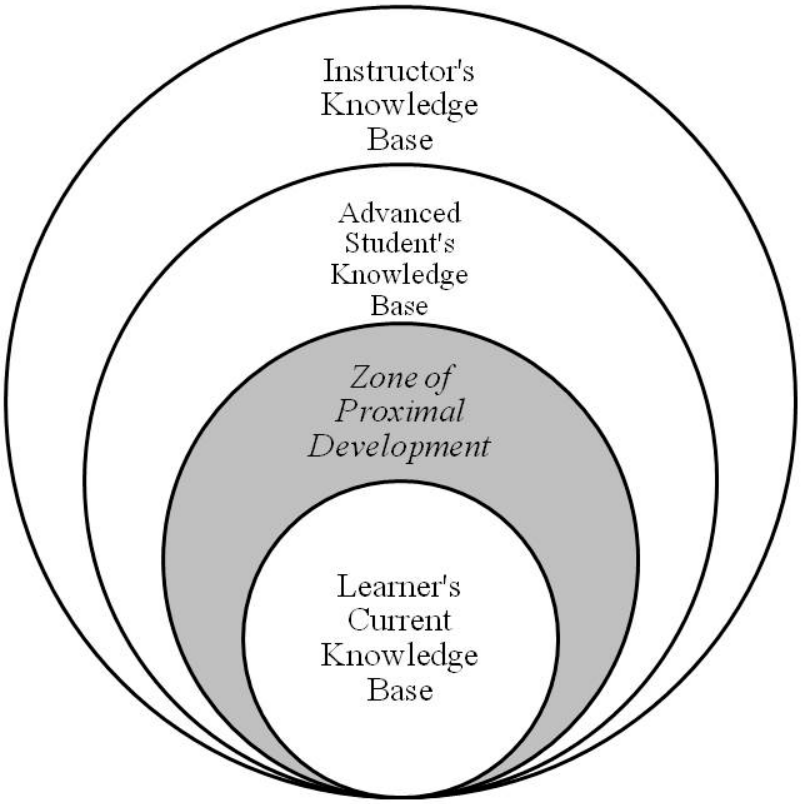

Figure 1-2: The Zone of Proximal Development

The face-to-face learning environment has been around for centuries and offers human-human interaction that many experts believe is integral to learning. Significant guidance from more knowledgeable peers or experts is believed to elevate student abilities within the ZPD and is known as scaffolding. According to social constructivism, learning occurs when students share background information and participate in the give and take of collaborative and cooperative activities. While they are negotiating the meaning, they are constructing their own knowledge (Wink, 2002; Maddux, 1997; Wertsch, 1992). The principle of social constructivism

promotes students' deep understanding and creativity (Wink, 2002). Although social constructivism has typically been thought of as a F2F mechanism, there is no reason why it cannot take place in other learning environments (Sthapornnanon et al. 2009). An online setting allows instructors to consistently embed social constructivism into the learning process. The asynchronous mode of online communication provides participants with more time to think and an equal right to share their thoughts. Online or distributed learning environments that have emerged more recently have made it possible for learning to happen in remote locations and at all times of the day. Figure 1-3 shows the four critical dimensions of interaction that occur in F2F and online learning situations. Face-to-face learning has typically taken place in an instructor-directed, live, synchronous, high-fidelity environment. Distance learning, which was first offered a hundred years ago in the form of mail correspondence and has evolved into online courses, has emphasized self-paced learning that occurs in an asynchronous low-fidelity environment.

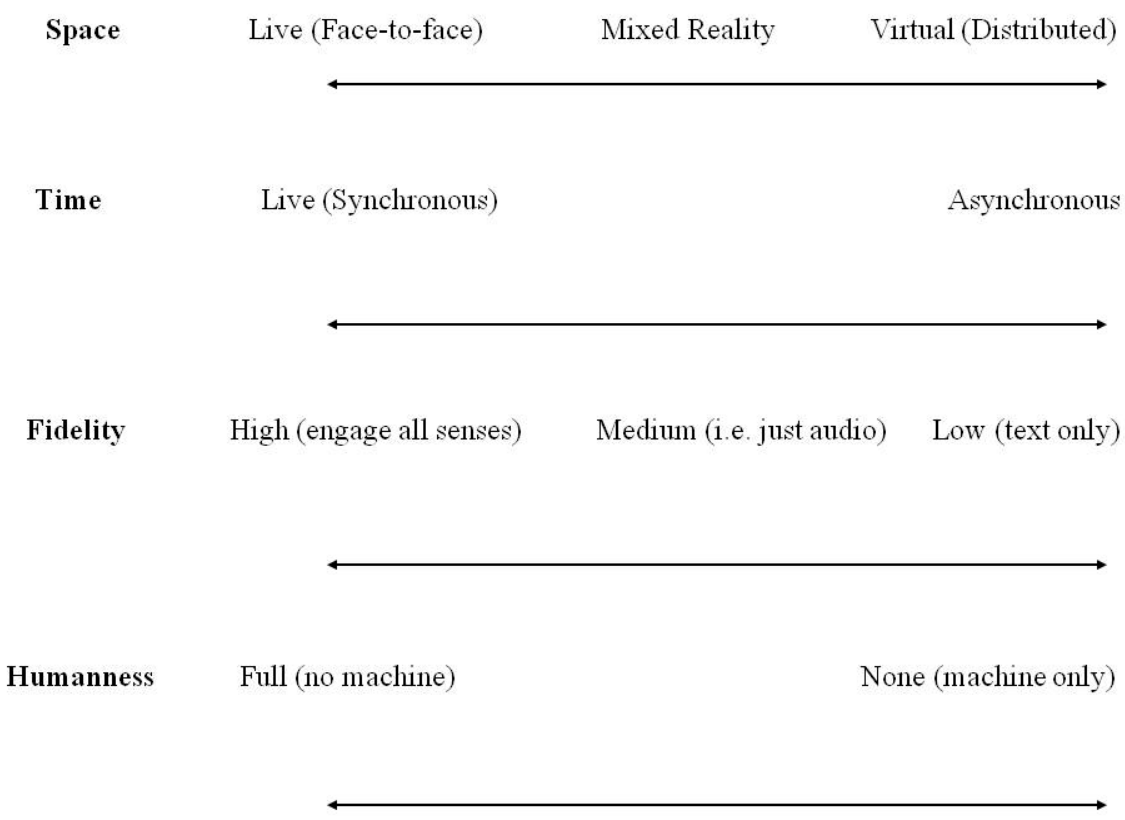

Figure 1-3: Spectrum of Learning Environments (Bonk 2006)

The two distinct learning environments have in the past remained separate entities because they used different methods of transmission and served different audiences. A bridge between the virtual and the live environment has been made workable by the rapid development of technology over the last couple of decades. These technologies have made the possibilities for learning in the distributed environment become more like the F2F environment (Osguthorpe and Graham 2003). Communication technologies allow learners and instructors to have synchronous interactions in real time with close to the same levels of fidelity as the F2F environment. For example, online office hours are possible and may be better attended than traditional office

hours. The widespread availability of digital learning technologies has led to the integration of computer-mediated instruction (CMI) elements with F2F learning experiences. The trend towards this blending of technologies and learning environments is becoming more and more common on today's college campus (Lovell 2009; Sancho et al. 2006). The question is not whether blending is happening or necessary, but how to create the most effective mix of CMI and F2F instruction to offer the best of both worlds to today's learner.

Blended learning systems can be defined as the convergence of F2F instruction with CMI. In 2002, the *Chronicle of Higher Education* quoted the president of Pennsylvania State University as saying the convergence between online and face-to-face instruction was "the single-greatest unrecognized trend in higher education today" (Young 2002). The editor of *Journal of Asynchronous Learning Networks* was documented in the same article as predicting an exponential increase in the number of hybrid courses (i.e. blended) in higher education offered on college and university campuses (Young 2002).

Section 1.2 Rationale for Research

Many studies have documented the fact that online learning (OL) and face-to-face (F2F) learning are comparable in student outcomes (Mayadas, Bourne, and Bacsich 2009). Research into comparing student outcomes of blended learning (BL) is a newer area. Current research suggests that BL is also comparable to F2F learning (Tempelaar, Rienties, and Giesbers 2009; Larson and Sung 2009; Bonk and Graham 2006). Research of BL in a pharmacy setting is relatively scarce. Initial studies suggest that it is likely to produce favorable student outcomes (Crouch 2009; Zapantis et al. 2008).

The pharmaceutical calculations class at KU SOP (Pharmaceutical Chemistry 517, PHCH 517) was chosen for study as it is an introductory class which does not require advanced

math skills. Due to the straightforward content of the class, moving lectures online was considered to be something students would readily accept. The primary objective of the class, repetition of calculations to reduce error is best accomplished by working problems. Class time was reserved for working problems. Students could then watch lectures online at their convenience.

Section 1.3 Research Questions

This study sought to answer two basic questions:

1) Will blended learning in an introductory pharmacy class produce student outcomes comparable to a face-to-face class?
2) What are student attitudes before the introduction of a new class format?

Section 1.4 Significance of the Study

Because very little research on blended learning in a pharmacy class has been reported, the implications for this research would be significant. As pharmacy schools seeks to expand enrollment, while at the same time face ever-dwindling resources, the cost benefit of blended learning cannot be discounted. Blended learning courses can become one tool in the administration's tool belt for providing quality instruction to a wide diversity of students, to a range of locations, and with a variety of resources.

Section 1.5 Definition of Terms

Several terms are used in this study and are defined here.

Asynchronous: Refers to digital communication in which there is no timing requirement for transmission of information between computers or individuals (email is an example).

Blended Learning (BL): A method of course delivery which is a combination of synchronous and asynchronous communication.

CMI: Computer Mediated Instruction

Delivery Format: The way that a course is attended or delivered

Distance Education (DE): A method of course delivery in which the student and teacher are separated by time and space.

Face-to-Face (F2F): Students and teacher are in the same place at the same time.

Synchronous: Communication which is transmitted at the same time. Videoconferencing would be an example.

Small-groups: Groups of not more than 3 or 4 students.

Web-Based: Course that is delivered online, generally through a learning management system such as Blackboard (©2010).

Chapter 2

Review of Literature

Section 2.1 Background

The basic reason for going to college which has been to get an education and start a career, still holds true today (Croake 1973; Mitchell 1992). Access to higher education has never been easier than it is currently for students (Shea, Pickett, and Li 2005). Examination of enrollment numbers at degree granting institutions shows us that a wide range of learners are attending college, and their numbers are increasing. Table 2-1 provides student enrollments by age from 1990 through 2006 and projections through 2017 (US Department of Education 2008). Closer inspection of this data shows that it is the students older than 25 years that make up a sizeable percentage of total student enrollments and will continue to do so for the foreseeable future.

Numbers in Thousands	1990	1995	2000	2001	2002	2003	2004	2005	2006	Projected 2008	2012	2017
Total	**13,819**	**14,262**	**15,312**	**15,928**	**16,612**	**16,911**	17,272	**17,487**	**17,759**	**18,200**	**19,048**	**20,080**
14 to 17 years old	177	1148	1145	1133	2202	1151	2200	1199	2231	1191	1190	2211
18 and 19 years old	2,950	2,894	3,531	3,595	3,571	3,479	3,578	3,610	3,769	3,953	3,940	3,960
20 and 21 years old	2,761	2,705	3,045	3,408	3,366	3,473	3,651	3,778	3,648	3,723	3,993	3,958
22 to 24 years old	2,144	2,411	2,617	2,760	2,932	3,482	3,036	3,072	3,193	3,289	3,584	3,753
25 to 29 years old	1,982	2,120	1,960	2,014	2,102	2,106	2,386	2,384	2,401	2,531	2,658	3,035
30 to 34 years old	1,322	1,236	1,265	1,290	1,300	1,368	1,329	1,354	1,409	1,434	1,616	1,813
35 years old and over	2,484	2,747	2,749	2,727	3,139	2,852	3,092	3,090	3,107	3,080	3,066	3,350

Table 2-1 Total Fall Enrollment in Degree-Granting Institutions by Age: Years 1990 – 2017 (DOE, 2008)

Americans of all ages are engaged in higher education. The reasons for going to college include finishing an advanced degree, upgrading job and technical skills, and intellectual stimulation (Picciano 2009). In many college classes, especially in large public institutions and community colleges with diverse populations, students continue to represent a broad spectrum of age groupings. The first charge of any college course should be to teach course content. Delivery of that course content can and should be designed to address a diversity of needs and learning styles, rather than specifically targeting a particular age segment.

Section 2.2 History of Distance Education

Distance education methods can be traced back more than a hundred years to the 19th century when improvements in postal services paved the way for correspondence courses. Since these early days, distance educational programming can be tracked back through five different stages of generations as listed in Table 2-2 (Taylor 2001).

	Five Generations of Distance Education
1	Correspondence Education
2	Multi-media model combined print, audiotape, videotape and CD technologies
3	Tele-Learning Model – synchronous communications like videoconferencing
4	Flexible Learning Model such as computer-mediated communications
5	Intelligent Flexible Learning Model – "campus portal access to institutional processes and resources . . . [that provides] a customizable e-interface [through which] students, staff and stakeholders can" interact with the University

Table 2-2: Five Generations of Distance Education (Taylor 2001)

As technology and research into learning has evolved, distance education has gone from a relatively rigid process that only occurred in specific times and places, to where it is today; a

fluid, dynamic process that can take place at anytime and anywhere. More than 75% of adults in the United States use the internet and 55% have high speed connections (Madden 2006; Horrigan 2008). These numbers represent potential learners to an institution. The primary driver for online education is the presupposition of faculty and university administrators that a sizable population of potential learners exist – typically, working adults who wish to obtain college credit but cannot do so because of work and family obligations.

Over the last 20 years, online educational programming growth has been exponential. Tallent-Runnels et al (2006) noted that by the year 2000, virtually 9 out of 10 institutions of higher education (2 and 4 year institutions) offered distance education programs. This equated to 2.8 million individuals enrolled in college-level credit courses using online delivery. Grandzol and Grandzol (2006) observed that online enrollments for U.S. institutions grew by more than 18% (from 1.98 to 2.35 million) between 2003 and 2004, matching growth rates over the prior three-year period. Business disciplines represented the highest levels of growth.

Basic technology requirements for online students anywhere in the world include access to a conventional personal computer with a broadband connection to the internet. Students and faculty interact in classes via course management software. Course Management Systems such as Blackboard (©1997 - 2010, Blackboard, Inc.), Angel (©2010, Blackboard, Inc) and Moodle (©1999, Moodle Trust) have become ubiquitous in higher education. These systems are used for both online and on-ground asynchronous instruction. Synchronous software is sometimes employed for simultaneous voice and text discussions. Many classes are conducted asynchronously meaning instructors and students are not communicating “live”. The most recent survey published in 2008 reports that just under 4 million students were enrolled in at least

one online course in the fall of 2007 (Mayadas, Bourne, and Bacsich 2009). Community colleges account for about 50% of online enrollment numbers.

Before 1996, the Department of Education (DOE) treated asynchronous online learning as conventional correspondence study which limited financial aid available to those students. In order for institutions to offer programs online and for students to secure funding, DOE requires that an institution has secured specific approval from its accrediting commission. One provision of DOE's Higher Education Opportunity Act is that, "An institution must establish processes through which the institution establishes that the student who registers in a distance education or correspondence courses is the same student who participates in and completes the program and receives academic credit" (Department of Education, Higher Education Opportunity Act, PL 110-315, 2008).

Adding online offerings to a department or program is not a decision to make without careful thought and consideration. Online education has most recently drawn the attention of college and university stakeholders such as accrediting agencies. These governing bodies must assess and evaluate an educational activity very different from traditional classroom teaching. In the process of on-line course design, institutions must be mindful of these agencies (Grandzol and Grandzol 2006) such as the American Association of Colleges of Pharmacy (AACP) which is the accrediting agency for pharmacy schools.

The AACP Commission to Implement Change in Pharmaceutical Education recognizes and addresses the need for a variety of new teaching strategies. In particular,

> "The decision regarding what strategy to employ and when to employ it should come as a result of the curricular planning process in which the interests and abilities of faculty to use different teaching strategies is measured against the perceived value of

different methods at specific times in the curriculum to facilitate student achievement of specific outcomes." (AACP 2010)

The Association to Advance Collegiate Schools of Business (AACSB) recommends that:

> "Educators should design learning experiences to take advantage of various modalities that best fit with learning objectives and with student learning styles" (AACSB 2010).

The pedagogy should be the driving force when designing a course. Alternate delivery formats such as web-based can be considered if it meets course objectives and curricular outcomes.

When considering whether to offer a course or several courses online, faculty members and departments have to consider the benefits and drawbacks. Grandzol and Grandzol (2006) summarized the following advantages and disadvantages (Table 2-3):

Advantages	Disadvantages
▪Improving the technical literacy of students	▪Poor quality of instruction
▪Minimizing projected shortages in instructors	▪Training costs for faculty
▪Alleviating overcrowding and/or reduced investment in college physical plants	▪Evoking faculty resistance to change
▪Increasing enrollment and profits	▪Lack of student-teacher interactions
▪Creating a more friendly learning environment	▪Employer skepticism
▪Allowing students to work at their own pace	▪Increased faculty workloads
▪Extending geographic reach and presence of an institution	▪The inappropriateness of the medium for teaching certain types of course content
▪Improving graduation rates	▪Loss of scholarly control
▪Reducing costs associated with commuting and other work demands	▪Problems in technology and administration

Table 2-3: Advantages and Disadvantages of Online Education (Grandzol and Grandzol 2006)

The strategic plan of a department or university can sometimes help to decide if the advantages outweigh the disadvantages. Are the time and resource costs justified by the benefits to the students? Often, the specifics of the course and the technology considerations have to be considered when deciding to offer a course online. Specifically, two kinds of technology are involved in distance or online education. Instructional technologies use social-psychological research in organizing course content into instructional programs in order to produce learning,

while delivery technologies focus on providing efficient and timely access to instructional material (Grandzol and Grandzol 2006).

The “humanness” of F2F contact can be hard to replicate in an online learning environment. In framing discussions of online learning, the American Association of College of Nurses (2000) considers, how well does online learning prepare nursing students for the social and behavioral skills needed in a field noted for its people-intensive work? While experiential courses may not seem an obvious choice for online format, the objectives of the course should always be considered and seeing if some amount of material or courses could be offered online if the delivery format was sound.

Recommendations for structuring a high quality online course can be modeled after Chickering and Gamson’s recommended good practices for higher education summarized in Table 2-4 (Chickering and Gamson 1987).

Good Practice in Undergraduate Education	
1	Good practice encourages student-faculty contact.
2	Good practice encourages cooperation among students.
3	Good practice encourages active learning.
4	Good practice gives prompt feedback.
5	Good practice encourages time on task.
6	Good practice communicates high expectations.
7	Good practice respects diverse talents and ways of learning.

Table 2-4: Good Practice in Undergraduate Education (Chickering and Gamson 1987)

Hazari and Snorr (1999) noted that there were widespread opportunities for interaction and feedback between students and instructors in a Web-based course but observed that such opportunities are seldom utilized, particularly without proper instruction of the faculty and students. The most often used feature in Blackboard is the distribution of static documents (i.e. posting of PowerPoint Slides) which alone does not make a course a Web-based course or online course.

What types of learners are enrolling in online courses? It certainly depends on the institution. After conducting a survey of its enrollment in 2002, the The University of Central

Florida was surprised to find that almost 80% of its online learners were millenials, or students born after 1982 (Moskal 2009). Other universities may find that it is more non-traditional students that are in online classes (Mayadas, Bourne, and Bacsich 2009).

What does this mean for professors? Because the professorate is aging, not all faculty members wish to acquire the skills needed to engage with millennial students, who are quite adept at using wikis, blogs, Web casts, virtual worlds, and course management systems. Faculty members who subscribe to the mantra "I can't teach them if I can't look them in the eye" may slowly become obsolete except in some exclusive colleges (Mayadas, Bourne, and Bacsich 2009). The millennials are changing the way teaching and learning must be approached. Mobile learning with podcasts, text messaging, and Virtual worlds will be the future norm, giving faculty new tools through which to extend and enhance the educational experience (Hartman, Dzuiban, and Moskal 1999; Mayadas, Bourne, and Bacsich 2009; Ali, Hodson-Carlton, and Ryan 2004).

Section 2.3 Comparison of Online Learning with Face-To-Face Learning

Are students satisfied with online courses and have they had a high-quality learning experience? How do you compare the two delivery formats and is it a valid comparison? These questions are difficult to answer because huge variances exist in instructors' teaching skills and experience, course organization, and in study materials for students.

Research comparing online and face to face formats is not always straightforward and often has questions of validity. For instance, Dellana et al (2000) compared two sections of the same-quantitatively-oriented management science courses. The course, which is typically taken by juniors, was taught by the same instructor in both cases and covered the same content with approximately equal class size and instructional approach. The traditional version was taught in

a lecture format with Power Point Visuals, while the on-line course utilized the same material. Additionally, there was a discussion room and e-mail in the online version. All exams for both sections were given in an on-campus classroom. There was no statistically significant difference between the traditional and the online versions on average scores. While this may seem noteworthy, there are questions that need to be addressed. First, there are several threats to the validity of this study – students were not randomly selected but self-selected. Students know the class format before they select the section and they will pick the format consistent with their own comfort level. Another potential threat to validity would involve differences in an instructor's proficiency with teaching in the chosen class format (Anistine and Skidmore 2005). An instructor who is extremely versed in classroom teaching could presumably offer a different quality learning experience than if he had to do the same course online and for which his experience was limited. Sometimes comparing two different course formats of the same material is not a direct relationship. For example, an instructor could produce a low quality face-to-face lecture and a high-quality on-line course which can directly affect learning outcomes for students.

Test grades are often used as the basis of comparison between course formats. Referring to Bloom's (1956) taxonomy, in which Benjamin Bloom identified levels of intellectual behavior important in learning (Figure 2-1), it is possible for tests to sample different levels of complexity of knowledge and cognitive processing (Mayadas, Bourne, and Bacsich 2009), Once again, this disparity could again be a threat to the validity of the data.

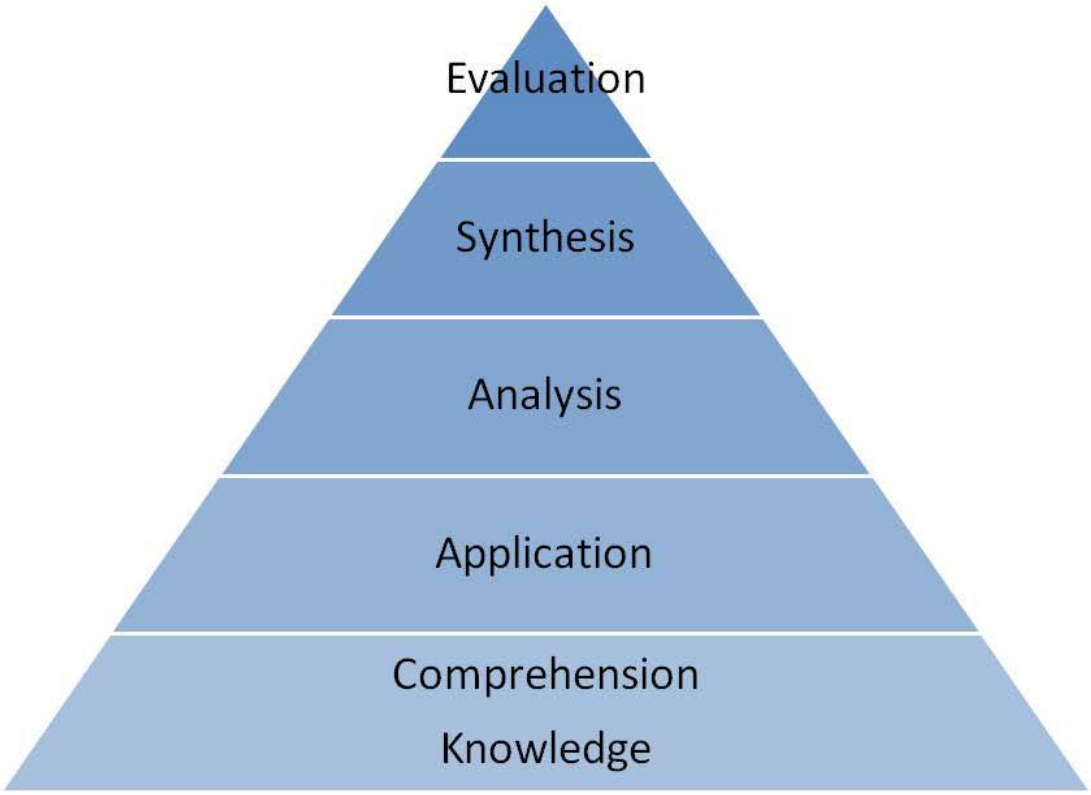

Figure 2-1: Bloom's Taxonomy of Learning (Bloom 1956)

Studies comparing different types of media are not new. As Clark (1983) points out, "Studies of the influence of media on learning have been a fixed feature of education research since Thorndike (1912) recommended pictures as a labor saving device in instruction." Since the introduction of the computer, numerous studies have been conducted to determine whether the use of the computer improves learning. Kulik (Kulik, Kulik, and Cohen 1980; Kulik, Kulik, and Bangert-Drowns 1985; Kulik and Kulik 1991) and his colleagues conclude in their meta-analysis of numerous studies that "computer-based instruction (CBI) usually produces a positive effect on students." Clark (1983) on the other hand finds that, "Consistent evidence is found for the

generalization that there are no learning benefits to be gained from employing any specific medium to deliver instruction." Kozma (1994) argues that success is found when the "capabilities of the medium" are employed. Marshall McLuhan (1967) foreshadowed the rise of asynchronous education when he stated:

"The medium, or process, or our time – electronic technology – is reshaping and restructuring patterns of social interdependence and every aspect of our personal life. It is forcing us to reconsider and reevaluate practically every thought, every action, and every institution formally taken for granted. Everything is changing – you, your family, your neighborhood, your education, your job, your government, your relation to 'the other'. And they're changing dramatically." (McLuhan and Fiore 1967)

If online technology is available and utilized by faculty and programs, the next obvious question is whether learning outcomes are worse, the same, or better than traditional instruction.

A meta-analysis of studies comparing online or distance education with a traditional format was done by Russell (1999). Three hundred and fifty studies from 1928-1999 that supported the finding of NSD in learning outcomes for DE were targeted in this study. It might be somewhat disconcerting that Russell picked studies that supported NSD.

Not all studies support NSD unanimously. Shacar and Neumann (2003) identified 86 studies (representing more than 15,000 students) between the years of 1990-2002 that had no severe methodological flaws, included a control or comparison group, and had sufficient data to calculate an effect size. One third of the studies found negative results where the traditional format outperformed the on-line format. Two-thirds of the studies found positive effects. Of that positive group, 35% found a small effect, while the rest observed a medium or a large effect.

Adequate details about specific studies was not included, so even these suggestive results leave questions about the sources of the data.

Three meta-analyses do deserve attention due to their rigorous methodology and analysis. Bernard et al (Bernard et al. 2004) identified 232 studies comparing DE with F2F class format from 1985 through 2002. DE was defined in this instance as relatively permanent separation, both in time and space. The studies had to include an empirical comparison of the DE format with F2F. The level of the learners had to be identified, and studies had to be for specific courses. Three different dependent variables were noted: achievement outcomes, attitudes, and retention. Studies were coded, including course design formats, media use, and subject matter. Effect sizes were weighted. There was a very small yet significant difference in achievement scores favoring DE over classroom-based education (N=55,000 students total). There was a large variability in outcome scores for both formats. Some distance education applications are much better than classroom instruction, some are much worse. Asynchronous DE programs were significantly better while synchronous were significantly worse. Further analysis indicates that differences were attributable to the methodology employed and pedagogical features of the instruction. Media or technology factors did not predict achievement. While there were no differences between studies of undergraduates, graduate school studies yielded modest, significant results in favor of DE. F2F was found to be better for topics such as math, science and engineering while computing and military/business topics seems to be slightly better in DE. Findings about people-intensive fields of practice such as nursing, counseling, or education were not reported, probably due to the lack of studies in these areas.

When looking at student opinion, DE was significantly associated with negative attitudes. This difference held for synchronous but not for asynchronous DE. There was a large variance in attitude scores. Retention rates were significantly lower for online courses.

From these studies, we cannot conclude that DE or F2F is better in terms of student outcomes. Both DE and F2F can work well, or they can work very poorly. Clearly a variety of factors need to be considered, such as student demographics, instructor experience, technology support on campus, and course objectives.

A study done by Sitzmann et al (2006) found 96 research reports from 1996 to 2005, representing 19,000 students in 168 courses. Two thirds of these studies involved undergraduate students. The primary dependent variables were declarative knowledge and procedural knowledge and skill. Web-based (WB) instruction was significantly but weakly more effective than F2F in teaching declarative knowledge. There were no differences between WB and F2F on procedural knowledge. Combining WB and F2F into one class format produced better outcomes than either class alone.

Zhao et al. (2005) also compared the two course formats and found 51 applicable studies, yielding 99 effect sizes for almost 12,000 students. Like the Sitzmann et al. study, they were able to code the dependent variables. On-line courses were slightly more effective than F2F courses, although the difference in this study was not statistically significant. There was a larger variance in effect sizes for both formats. They found that studies published after 1998 were significantly more likely to report distance education being more effective. Student self-assessment of learning tend to favor F2F while other metrics such as grades or attitudes, favor DE. That is, DE students think they are not learning as much when in fact they are. Like Sitzmann, Zhao found that the combination of DE and F2F seemed to be the most effective.

Three factors tend to positively skew DE: instructor involvement, media involvement, and type of interaction (both synchronous and asynchronous interaction was best). When instructor involvement is low, the outcome of DE is not as positive as F2F, when instructor involvement increases, DE programs yield more positive outcomes. Clark (Clark 1994) originally proposed that DE is technology neutral which is supported by these studies.

One factor for more favorable student outcomes in WB courses could be the drop-out rates. There are differential retention rates between WB and F2F – more students drop out of WB. A reasonable assumption is that those students that drop out are doing poorly. Thus the students that are left in the class will be positively skewed, which can definitely affect student outcomes. The other threat to validity comes from pre-existing differences. Students typically self-select based on course format. Online students differ in demographics – perhaps they have prior knowledge and experience, and different levels of motivation.

In general, the body of research comparing online courses with traditional format has concluded that there is no significant difference in outcomes (Mascuilli 2000; Allen and Seaman 2007; Mayadas, Bourne, and Bacsich 2009; Allen and Seaman 2005; Cooper 2001; Fjermestad, Hiltz, and Zhang 2005; Kim and Bonk 2006; Rivera and Rice 2002; Seaman and Allen 2008; Tallent-Runnels et al. 2006; Swan 2003; Fallah and Ubell 2000; Newlin, Lavooy, and A.Y. 2005). Additionally, the website, http://www.nosignificantdifference.org, has collected hundreds of articles showing that there is no significant difference between face-to-face and online delivery modes. Well-designed online courses taught by experienced instructors tend to result in at least equivalent outcomes for both online and traditional students.

Section 2.4 Discussion of Blended Learning

If "no significant difference" exists between F2F and DE, what can be said about combining the two delivery formats into one class? Faculty, instructional designers and researchers started to be interested in uniting the two course formats for a variety of reasons. How can colleges and universities attract and retain a wide variety of students and address their learning needs, while at the same time considering the institutions resources?

A core construct of instructional reform focuses on "evidence-based education" (Blouin et al. 2009). Good instructional design promotes better learning outcomes. The importance of good instructional design has stimulated several initiatives in higher education in which a team of individuals collaborate in the design of a course. The National Center for Academic Transformation (NCAT) provides leadership to help colleges and their faculty use information technology to redesign learning environments that produce better learning outcomes for students and reduce the institution's cost (Blouin et al. 2009). At most institutions, course redesign has been accomplished with large enrollment courses where the potential (and data) is significant.

For the development of educational practices that go beyond the traditional lectures, the time that must be dedicated to the teaching mission could increase markedly, making it increasingly difficult for faculty members to balance the traditional triangle of service, scholarship, and teaching. Garnham and Kaleta (2002) suggest it may take up to 6 months to develop an online course. Blended learning environments, where students are responsible for a portion of their learning on their own, will at least initially require more faculty time to monitor. This time investment could be frontloaded to design the environment, and less time would be spent during the semester because students would be increasing responsibility for their learning. In addition, strategies are reusable year to year, requiring only minor updates.

Is Blended Learning just another course delivery format or does it offer something that CMI and F2F alone do not? Graham, Allen, and Ure (2005) found that BL is chosen for the following three reasons: (1) improved pedagogy, (2) increased access and flexibility, and (3) cost-effectiveness.

Improved Pedagogy. How can blending computer mediated instruction with in-class lecturing improve pedagogy? By going back to Chickering and Gamson's good practices (1987) in undergraduate education, blended learning has the advantage of being able to offer mulitiplicities of good practices.

Instructors have found that blending learning strategies allows the level of active engaged learning to increase both in the classroom and online (Collis, Bruijstens, and van der Veen 2003; Hartman, Dzuiban, and Moskal 1999; Morgan 2002; Smelser 2002). Peer-to-peer learning can take place in the classroom and continue in online discussion boards. Learners can take material presented in the classroom and use online tutorials to cement information, and conversely, take material presented online and use in-class face time for problem-solving.

Increased Access and Flexibility. Growth in access to the technology has allowed learners to learn anytime, and anywhere. Flexibility is crucial for more mature learners with outside commitments that would otherwise make attending classes impossible. The convenience of being able to attend classes from your home is often cited as an advantage of online classes. Social interaction and face-to-face contact is still important to many students and they appreciate being able to reduce but not eliminate seat-time in their courses. The University of Phoenix model allows F2F contact at the beginning of a course and the end of the course, with CMI in between (Bonk and Graham 2006).

Increased Cost-Effectiveness. Colleges and universities have appreciated the ability of blending learning systems to affect the bottom line – namely, BL can reach a large audience in a short amount of time while reducing the need for classrooms, personnel, and equipment. The Center for Academic Transformation with support from the Pew universities recently completed a three-year grant program in which the goal was to look at ways of using technology to enhance the curriculum while reducing costs (Pew 2003). IBM and Microsoft have both utilized BL in their corporate training and education (Bonk and Graham 2006) which has resulted in a large return of investment (ROI). Many universities certainly seek to see the same ROI by utilizing BL.

In order to better understand BL systems, we need to look at general categories of blending (Table 2-5).

Categories of Blended Learning Systems	
Enabling Blends	Focus is on issues of access and convenience. Provides mostly flexibility to learners and/or reinforce learning experience in a different modality.
Enhancing Blends	Incremental in changes to pedagogy but not radically different. May provide additional resources and supplements online or vice versa.
Transforming Blends	Radical transformation of the pedagogy. Model changes from learners receiving information to actively constructing knowledge through interactions F2F and online. These blends are not possible without the technology.

Table 2-5: Categories of Blended Learning Systems (Bonk 2006)

Enabling blends are the most common blend occurring in programs. With widespread adoption of Learning Management Systems such as Blackboard (©2010) and technology-equipped classrooms, universities are able to offer some level of technology enhancement to a F2F class. As instructors become more adept at using the technology, enabling and enhancing blends become more commonplace. It usually takes a level of comfort at that level before more transformative blends can occur.

Transformative blends are seen more frequently in the corporate environment. The availability of expensive technology can explain this trend. In higher education, instructors are limited by many factors such as class size, duration, location, and availability of technology. In

spite of this, a small but growing number of faculty are experimenting with technology-mediated approaches to teaching that can transform the way students learn (West and Graham 2005).

Live interaction is integral to the learning process and will continue to be even in the digital age. Many learners prefer the live component of a BL experience for the social interaction that aids learning. Human interaction such as the formation of learning communities and collaborative learning are integral to the *Learning Paradigm* (Fink 2003).

Online learning often requires a tremendous amount of self-discipline that depends on the maturity of the student. BL environments should be designed with consideration for learner maturity and capability for self-regulation.

Are there particular students who will profit most from a blended learning format? Tempelaar et al (2009) looked at the demographics of an introductory statistics class and how the learners used the resources available to them in a blended learning format. Researchers found that less academically inclined students such as those with superficial approaches to learning, profit most from the availability of e-learning tools.

Section 2.5 Pedagogical and Design Aspects of a Blended Learning Course

The blended learning model is becoming the preferred model for online course design (Bonk, Wisher, and Lee 2003; Osguthorpe and Graham 2003; Garrison and Kanuka 2004). There is ambiguity in the literature and in the field regarding the proper implementation of blended learning and the optimal proportions between OL and F2F. Researchers agree that there needs to be more research on BL to establish standards for effective course design and implementation.

Instructional designers for BL courses have to consider a variety of challenges known to exist. For instance, digital text is thought to be inferior to printed text in terms of readability and orientation (Bonk and Graham 2006). Loneliness and isolation have a negative impact on learning achievements (Lazenby 2003; Coates 2006; Bates and Khasawneh 2007; Kurtz and Amichai-Hamburger 2008). Instructors must be mindful of this and seek to optimize the social environment of a class by providing the right amount of F2F time in a BL format. The gap between learners, peers, and instructors must be bridged to achieve positive learning outcomes.

Another factor to consider are digital skills of both instructors and learners – teachers and students sometimes lack the necessary cognitive skills for making effective use of online technologies (Eshet 2004, 2007). Shemla and Nachmias (2006) point out that a lack of skills leads to an uneducated use of instructional technologies so there must be sufficient resources for the educating of faculty and students on the use of these technologies. Course success can be determined by the student's digital literacy. In fact, as computer skills increase, so does student satisfaction with online courses (Ali, Hodson-Carlton, and Ryan 2004; Muilenburg and Berge 2005; Tallent-Runnels et al. 2006). Digital literacy can include one's understanding of common online instructional methods or experience with software or hardware.

In spite of these issues, blended learning can emerge from these issues as a superior class format. Typically, BL makes extensive use of learning technologies through the blend of physical and virtual environments in order to supplement traditional F2F learning (Singh 2003; Bersin 2004; Bonk 2004; Rovai and Jordan 2004). A wide variety of BL models are described in the literature (Singh 2003; Thorne 2003; Bonk and Graham 2006), ranging from supplementing the F2F learning process with online materials, as in most traditional universities (Shemla and Nachmias 2006), to conducting the learning via a learning management system (LMS)

supplemented by a few F2F orientation meetings. This latter approach is common in most open or distance universities (Guri-Rosenblit 2005). Allen and Seaman (2007) describe blended learning as a course which delivers 30 - 79% of the material online. Most papers on blended learning indicate that there is no ultimate formula for blending the online and F2F learning components and emphasize the challenges faced by designers of blended learning to achieve the best proportion in every learning situation (Rossett et al, 2003; Bersin, 2004; Dentl and Motsching-Pitrik, 2005).

Many universities are developing long-term strategies for the effective implementation of online instructional programming (Allen and Seaman, 2005). Blended learning makes up a greater portion of that growth each year (Dukes et al, 2006). Diversity among college students has been on the increase for some time. What has been thought of as traditional students; those students that are full-time students, 18-22 year olds, Caucasian, and male constitute only 27% of the student body at postsecondary institutions (Choy, 2002). Those considered nontraditional include first-generation college students, students with disabilities, students older than 25 years, and those that are racially and ethnically diverse (McGuire and Scott, 2006).

Higher education is traditionally thought of as an academic environment oriented towards content demands; that is, we expect students to focus on the meaning or message being presented by the instructor. Blended instruction is shifting the classroom experience from one that has been exclusively F2F and primarily teacher-directed to one that is online and primarily student-driven. The online environment requires that faculty devote attention to the design and delivery techniques that are used to meet instructional goals. Students must develop new skill sets and acclimate themselves to the online environment before they can effectively access course content (MacDonald, Heap, and Mason 2001). Accessibility and digital literacy must be considered

when developing curricula that use digital media (Luke 2007). Online instructional environments pose numerous challenges. Self-motivation is critical to student achievement in the online environment (MacDonald, Heap, and Mason 2001). Other factors include the ability to manage one's time effectively and to work and learn independently. College instructors and administrators with expertise in online learning indicated that self-regulation is the most important factor for student success in web-based academic settings (Kim and Bonk 2006). Students have indicated that they consider communication the second-most important factor for success in an online course (Kieser, Kollar, and Schmidt 2006).

Great diversity exists among students who are accessing higher education. A clear reformulation of instructional content and instructional pedagogy is certainly required to address the diverse learning characteristics of today's higher education students. Group work is one way to put the principle of tolerance for error into practice. In F2F meetings, instructors can structure peer-tutoring opportunities. The advantage of immediate peer (formative) feedback is clear and compelling. The instructor ultimately provides summative feedback.

Allen and Seaman (2007) tracked online enrollments for five years and estimated that there were approximately 3.5 million students or almost 20% of higher education population enrolled in fully online courses in American colleges and universities in 2006-2007. There are few if any estimates of the number of students enrolled in blended courses. First, the definition of blended learning is not generally defined or accepted. As the mystique and aura of teaching online that was present in the late 90's disappears, the faculty no longer see themselves as doing something unique and special. Colleges and universities are not necessarily keeping accurate records on faculty who teach blended learning. The lack of mechanisms for incorporating

information on blended courses in college databases creates a situation in which a large-scale study becomes difficult to conduct and vulnerable to misinformation.

Without administrative systems in place for identifying blended learning courses and without a widely accepted definition or taxonomy, collecting data on blended learning becomes difficult. At the same time, there is a belief that colleges and universities are not doing enough to use the available technologies to engage students in meaningful explorations of content and curricular materials (Florida et al. 2003; Rogers, Oblinger, and Hartman 2007). Marc Prensky (2001) initiated the popular "digital natives versus digital immigrants" thesis, which hypothesizes a disconnect in the way younger and older generations use technology. While young people may be using technology in greater number than adults, the quality of its application to education is unknown. It may be the case that faculty are actually more knowledgeable and use the technology more effectively for education purposes. Despite the lack of hard data, it is accepted that colleges and universities need to do more to engage students. Online technology is perceived as one of the mechanisms that will foster this engagement.

Judith Eaton, President of the Council for Higher Education Accreditation (CHEA), the national coordinating body for national, regional, and specialized accreditation states that "We at the CHEA struggle to bring some order to the avalanche of information about both distance learning and quality assurance" (Mayadas, Bourne, and Bacsich 2009). Most universities have invested in course management systems such as Blackboard (©2010) and have established the requisite support structure to maintain technological stability for their online learning activities. Furthermore, they are providing the necessary leadership in tying online learning to institutional goals and objectives related to the broader issues of student access to education and academic program quality. In sum, the current environment in higher education requires the consideration

of online technology in confronting a number of issues related to teaching, learning, student access and academic program quality. Blended learning should be seen as one of the important pedagogical approaches that can help in this regard (Niemac 2009; Niemiec 2008; Precel, Eshet-Alkalai, and Alberton 2009).

Section 2.6 Comparing Modes of Instruction

Research comparing blended learning with other delivery formats is not plentiful in the literature. One study by Larson and Sung (2009) sought to determine if there was a significant difference in student success in an introductory management information systems class delivered in three different modes; F2F, blended and online. All class sections used the same textbook and supporting materials. The F2F sections followed a typical F2F format with the textbook and lectures being the primary mode of providing content to students. Students did have access to lecture notes available through a course management system online. The online sections were conducted in a typical online format. Textbook and lecture notes, delivered again through a course management system, were the primary modes of providing content to students. In the online section, students participated in weekly asynchronous online discussions. They were required to provide a comprehensive answer to discussion questions posted, as well as respond to another student's answer. Exams were taken at proctor locations.

The blended sections were a combination of F2F and online format. The class met in the F2F format 11 times and online 5 times. Three of the 11 in class sessions were used for exams. Students were required to participate in online asynchronous discussions with the same expectations as the online students.

There were 168 students total. Sixty-three were in the F2F, twenty-two in the online class, and eighty-three in the blended class. An analysis of the students enrolled in the class

indicates no significant difference in students based on race and age. However, there was a significant difference based on gender. The F2F and blended were similar, but the online had significantly more females. Several studies have shown that it is common for females to be the majority of enrollment in online classes (Cavanaugh 2005).

Section 2.7 Current Pharmacy Education

In order to understand how blended learning fits into the pharmacy curriculum; the structure of the program needs to be examined.

A doctorate of Pharmacy (Pharm. D.) is the only professional degree awarded in pharmacy schools in the United States. At the University of Kansas School of Pharmacy, (KU SOP), students are admitted into their first year of pharmacy school after two years of preparatory work which includes two semesters of general chemistry with laboratory, two semesters of organic chemistry with laboratory, two semesters of general biology with laboratory, one semester of physics, one semester of calculus, one semester of microbiology, as well as electives. The traditional entry for pharmacy school is to apply the fall of a student's sophomore year for entrance the fall of their junior year. Students do not enter KU SOP at any other time than in their fall year. For entrance into pharmacy school, several characteristics of an applicant are examined. These factors include among others; pre-pharmacy cumulative GPA (referred to as preRx-GPA) which would include the GPA of all courses taken prior to entrance to pharmacy school; pre-pharmacy chemistry GPA which would include two semesters of general chemistry with laboratory and two semesters of organic chemistry with laboratory, cumulative scores of the pharmacy entrance exam which is referred to as the PCAT (© 2010 Pearson Education Inc.), and scores of the chemistry section of the pharmacy entrance exam, the PCAT – chem. section. All of these characteristics are the applicant's pre-professional portfolio.

The PCAT is an exam developed by PsychCorp, a brand of Pearson. The PCAT is a specialized test that helps identify qualified applicants to pharmacy colleges. It measures general academic ability and scientific knowledge necessary for the commencement of pharmaceutical education. The PCAT is constructed specifically for colleges of pharmacy.

The PCAT consists of 240 multiple-choice items and two Writing topics. Candidates are given four hours to complete the test (plus administrative time for instructions and time for a short rest break about halfway through the test) (Pearson HigherEducation 2010)

All of these characteristics are included in the applicant's pre-professional portfolio. After admittance into KU SOP, the professional program includes both didactic and experiential coursework. The first three years of pharmacy school are typically mostly didactic coursework with experiential coursework done in the summer between school years. The final year of pharmacy school is all experiential coursework. Table 2-6 shows the layout of the professional curriculum at KU SOP. Pre-professional course work requires two (or more) years to complete; the professional didactic and experiential coursework takes four years to complete.

	Fall	Spring	Summer
Year 1 &2	Pre-Professional Coursework		
Year 3	P&TX 630 Pharmacology I MDCM 601 Med Biochemistry I MDCM 602 Med Biochemistry Lab PHAR 500 Early Pharmacy Practice Experience PHCH 517 Calculations PHPR 620 Ethics & Intro to Law PHAR 507 Dean's Orientation & Introduction to Pharmacy	MDCM 603 Med Biochemistry II PHCH 518 Principles of Solution/Dosage Forms P&TX 631 Pharmacology II PHAR 502 Pharmacy Practice II PHAR 510 Laboratories PHAR 505 Immunization Theory and Practice Early Elective Option	Introductory PPE (Pharmacy Practice Experience)
Year 4	MDCM 625 Med Chemistry I P&TX 632 Pharmacology III PHCH 625 Pharmacokinetics PHPR 503 Pharmacy Practice III PHAR 515 Laboratories Early Elective Option	MDCM 626 MedChemistry II P&TX 640 Toxicology PHPR 646 Pharmacotherapy I PHCH 626 Biopharmaceutics & Drug Delivery PHPR 619 Health Care Systems PHAR 520 Laboratories Early Elective Option	Introductory PPE
Year 5	MDCM 627 Medicinal Chemistry III PHPR 647 Pharmacotherapy II PHPR 614 Pharmacy Management P&TX 633 Pharmacology IV PHAR 693 Clinical Pharmacokinetics 1 Departmental Electives PHAR 525 Laboratories	PHPR 648 Pharmacotherapy III PHCH 667 Introduction to Clinical Chemistry 3 Departmental Electives PHPR 621 Pharmacy Law PHPR 630 Drug Information/Biostatistics & Med Lit Evaluation PHPR 670 Physical Assessment PHAR 530 Laboratories	Year 6 Clerkships start in the summer following year 5 with each clerkship being 4 weeks in duration
Year 6	PHPR 652 Drug Information Clerkship PHPR Hospital Externship PHPR Community Externship PHPR Clerkship (X 6)		

Table 2-6: KU SOP Professional Curriculum

Key: *P&TX – Pharmacology and Toxology, MDCM – Medicinal Chemistry, PHAR – Pharmacy, PHCH – Pharmaceutical Chemistry, PHPR – Pharmacy Practice*

Section 2.8 Blended and Hybrid Learning in Pharmacy

Current estimates expect a shortfall of pharmacists in the United States (HRSA 2004). As of January 2008, over 5,700 chain community pharmacist positions remained unfilled in the United States. Shortfall is expected to continue to rise while the number of prescriptions

dispensed is estimated to increase. By 2030, about 10% of positions will be unfilled (HRSA 2004).

Some schools of pharmacy have plans to increase student numbers by adding satellite campuses. For the University of Maryland School of Pharmacy implementation of a satellite campus would increase enrollment by 33%. The opening of the satellite campus was of intense interest to the Accreditation Council for Pharmacy Education, (ACPE), which noted that overall comparability between programs should be maintained, particularly in the areas of curricular delivery and outcomes and student services and satisfaction with these services (Elliot et al. 2009).

Development of the new distance program at Maryland included many technological revisions. A hybrid or blended delivery class format was chosen, utilizing both synchronous (videoconferencing) and asynchronous (recorded lectures available over the internet) technologies as well as live, F2F small group activities.

Finally, when comparing the two campuses, statistical analysis found that student academic performance, based on graded examinations and quizzes, was generally equivalent between campuses, or stated another way, there was no significant difference between blended learning as a class format on the satellite campus, and traditional, F2F class format on the main campus.

Crouch (2009) used a blended learning format to teach an elective cardiology pharmacotherapy elective to advanced pharmacy students. The blended learning format was used for four main reasons: 1) to efficiently augment student knowledge regarding cardiovascular drugs; 2) to enhance student preparation before attending class; 3) to improve and develop unique interaction among students; and 4) to economically provide the elective course

(from both a time and resource standpoint) twice yearly. Although he did not directly compare the blended learning format to a traditional format, he found that the BL format did effectively teach course content to students and they retained the information well enough to do better on subsequent assessment of cardiovascular knowledge before completing their advanced pharmacy practice experiences (APPE's) when compared to students who did not take the elective in a BL format.

Zapantis et al (2008) also used a BL format to teach an elective course to advanced pharmacy students. They found that the format was able to effectively teach course content and students were satisfied with the course format.

The ongoing shortage of pharmacists nationwide has generated the need to increase pharmacy training opportunities. A number of pharmacy schools have begun using a distance-education model, allowing for greater geographic coverage, use of cutting-edge technologies, and maximal use of existing facilities. Student performance in distance based settings has been inconsistent (Elliot et al. 2009). This inconsistency in student performance results underscores the need for continued research into the performance levels of students in contrasting academic settings and further investigation into the causes and consequences of student performance differences. Blended learning certainly shows great promise in a pharmacy education setting. Unfortunately, there is a paucity of research on BL within the context of didactic pharmacy coursework. This study seeks to explore the feasibility of BL in a pharmacy educational setting.

Chapter 3

Methodology

Section 3.1 Research Design

The purpose of this study was to determine if a blended learning class format for an introductory pharmacy class, specifically pharmaceutical calculations, would produce student outcomes equivalent to a traditional class format. Student attitudes were surveyed to see if students would accept this new class format.

There are two essential components of this study. First, the pharmacy classes must be compared to each other to if there is a demonstrable difference between the classes. The criteria used to compare these classes are the grades of the incoming students (pre-pharmacy GPA) and the Pharmacy College Admission Test (PCAT) comprehensive scores. Kuncel et al (2005) found that pre-pharmacy GPA combined with PCAT scores were moderate to strong predictors of academic success in pharmacy school.

This study could be described as causal comparative or ex post facto (Lodico, Spaulding, and Voegtle 2006), because the goal was to assess the student outcomes for three different classes of students in the KU SOP. Students were not randomly selected to groups. Instead, each entire class of students had a class format and the final course outcome was examined. The independent categorical variable was the class year (and the instructional strategy), while the dependent variable was final course grade. The statistical analysis used to answer the main research question was Kruskall-Wallis H and Mann-Whitney U, both non-parametric tests used for data that does not have a normal distribution.

A survey instrument taken from Cascaval (2008) was used to solicit student opinions and answer the second question addressing student attitudes prior to the course.

Section 3.2 Study Population and Setting

Pharmaceutical calculations (PHCH 517) is a 2 hour credit class taken in the first semester of the first year of a student's professional curriculum at KU SOP. Being able to accurately perform calculations is a critical component in patient care (Brown 2003). Pharmaceutical calculations are not difficult from a computational sense, but they deserve meticulous attention because flawless accuracy does matter in the care of patients. The main objective of the pharmaceutical calculation class is to minimize error and maximize accuracy.

Three classes at KU SOP were chosen for comparison. The classes are referred to by their year of graduation. Each class includes all students that are enrolled in pharmaceutical calculations, which would be all students at KU SOP in their first year of pharmacy school. Because the entire class was used, these were samples of convenience, rather than random samples. The three classes were the class of 2009, the class of 2012, and the class of 2013. The class that had blended learning introduced as the class format was the class of 2013 with Dr. Eric Munson as the instructor. The class of 2012 also had Dr. Munson as their instructor for pharmaceutical calculations and was taught with a traditional lecture format. Finally, the class of 2009 had Dr. Elizabeth Topp as their instructor for pharmaceutical calculations and was taught with a traditional lecture format. Table 3-1 shows the characteristics for each class as well as metrics for the national average.

Class (Matriculating Year)	2009 (N = 88)	2012 (N = 105)	**2013 (N = 106)**	National (Entering 2008)
Percent Female	62 %	71 %	**57.5 %**	62%
PreRx GPA Composite	3.59 ± 0.29	3.65 ± 0.30	**3.54 ± 0.36**	3.5
PCAT Composite	79.10 ± 13.4	75.75 ± 14.6	**72.65 ± 14.7**	69
Instructor	Topp	Munson	**Munson**	
Class Format	Traditional	Traditional	**Blended**	

Table 3-1: Class Characteristics

The PCAT is the Pharmacy Colleges Admissions Test (Harcourt publishing) and is the standardized entrance exam taken prior to entry into pharmacy school. As is typical in pharmacy schools across the United States, KU SOP has more females than males in its class. The PCAT consists of seven subsections which consist of two writing sections, a section in chemistry, a section in biology, a section in reading comprehension, a section in verbal ability, and finally a quantitative section. The composite score is an average of the seven subsections. The score is a percentile ranking of a candidate's score compared to the national average.

The PCAT exam changed significantly in June of 2007. The class of 2009 took the former version of the exam. The classes of 2012 and 2013 took the newer version of the exam. Besides some format changes, the other significant change was the comparison group for student's scores. Percentile ranks earned before June 2008 were based on the previous norm group (all first time examinees for the previous year). The current standard is that a student is compared to the current PCAT norm group (all first time examinees in the previous 5 cycles of the exam). By comparing to all versions of the exam and all students nationally, average scores have decreased, which was seen at KU SOP.

Section 3.3 Class format

The format of the calculations class for the class of 2013 for this study was changed significantly from the previous year. The most significant change was that lectures were delivered online (asynchronously) instead of face to face. See Appendix B for Sample Screen Shot from Online Lecture. Class time was reserved for small group problem solving in the form of worksheets, which the instructor facilitated. See Appendix A: Syllabus for Pharmaceutical Calculations from Fall 2009, for a syllabus of the class. Students were expected to view the lectures and/or review the material in the textbook prior to the worksheets in class. See Appendix C: Sample In-Class Worksheet for an example of a worksheet.

The Textbook used for this class was *Pharmaceutical Calculations*. The class of 2009 and 2012 used the 12th edition by Ansel and Stoklasa (2005). The class of 2013 used the 13th edition by Ansel (2009).

Three midterm exams were given in-class and two exams were given online. See Appendix D: Sample Online Exam #1and Appendix E: Sample Online Exam #2 for examples of online exams delivered in Blackboard. Students additionally were expected to complete

homework and online tutorials over the course material. If students had a 95% average over the five exams prior to the final exam, they were exempted from the final exam and received an A in the course. Course grades were determined by their performance on the five exams, completion of homework, tutorials and worksheets, and by the final exam grade if they took it.

A voluntary survey was completed at the beginning of the class and was delivered online via Blackboard. The student's identity was not associated with the survey. The survey was to determine the attitude of students towards online learning and group work. Survey questions were adapted from Cascaval (2008) and delivered online via Blackboard. See Appendix H: Survey Questions for a listing of the questions.

Section 3.4 Creating Online Components of the Course

Creating the online components of the course was necessary prior to the beginning of the class. Camtasia Studio, Version 6, (© 1995 – 2010 TechSmith Corporation) was used to create the online lectures. The lectures were in PowerPoint, Microsoft Office 2007, (© 2010 Microsoft Corporation). Camtasia captures the screen and audio recording of the instructor. In addition, a tablet laptop computer, Hewlett Packard Pavillion TX2000 (© 2008 Hewlitt-Packard Development Company LP) was used which allowed the instructor to digitally ink the slides as he was talking and recording the lecture. The Camtasia files were then uploaded to Blackboard (©2010) using Symposium Live Multimedia (©2006 – 2009 SymposiumLIVE) as the publisher. The files could be streamed live or downloaded as an mp4 file for the students to view at their convenience.

Tutorials were created in SoftChalk Lesson Builder Version 5 (© 2002 – 2010 SoftChalk LLC). They were then uploaded to Blackboard where students could access via the internet (the

material just appeared as a web page). Once they completed the tutorial, their score was automatically uploaded into Blackboard.

The student survey was created in Blackboard via a survey pool and delivered in Blackboard.

Section 3.5 Student Outcomes

Statistical Analysis of the data was done using SPSS Statistical Software, Version 17 (© 2010 SPSS Inc, an IBM Company). Metrics of each class were analyzed to determine the appropriate statistical analysis. Classes were compared for equivalency in terms of two pre-admission criteria, pre-pharmacy cumulative GPA (referred to as preRx-GPA), and composite score from the PCAT exam (referred to as PCATComp). To compare student outcomes for all three classes, only the final course grade was used. A final grade of an A was 4 points, a B was 3 points, a C was 2 points, and an F was 0 points.

Section 3.6 Research Design Issues: Sources of Bias and Error

Any process of conducting research is subject to internal and external validity. The internal validity of this study could be challenged by the relationship between the classes and final course outcome which could be due to other factors besides course format. External validity could be challenged by the extent to which the results of this research can be generalized.

Internal Validity

The main challenge to internal validity was whether the three classes were equivalent in demographics prior to the class. Some pre-admission criteria were examined to address this. Another challenge to validity is the role of the researcher in the course – the researcher served as

the teaching assistant to the classes of 2012 and 2013. The third challenge may be that the researcher was married to the instructor of these classes.

External Validity

One challenge to external validity is whether the study can be generalized to other populations. As this study is more exploratory in nature, generalizability can be discussed, but future studies are certainly warranted and can speak more to external validity.

Survey Instrument

The survey instrument used to assess student attitudes was adapted from Cascaval (2008). For purposes of this study, the only intent was to determine the subjective point of view of the students. It is helpful to assess students previous experience with a variety of technology and their attitudes towards technology in the classroom. Their attitude can directly impact their experience in a class reliant on that student's ability to utilize the technology (Muilenburg and Berge 2005).

Chapter 4

Results

Section 4.1 Data Analysis

To examine the original hypothesis, two issues need to be considered. First, were the background and capabilities of the students in the three classes studied similar? If the demographics of the incoming classes are dramatically different, then the results could be biased. The second part of the chapter is to compare the performance of the classes when the class presentation format was changed from traditional or face-to-face (F2F), to blended learning (BL). Did the performance of these students in the classes demonstrate that they learned as well with BL as in a F2F environment? Final grades in the class were used to compare class performance. Descriptive statistics about the different classes is presented as well as statistical analysis of student outcomes in this chapter.

For all of these analyses, an alpha value of 0.05 is used (95% confidence level). This confidence level represents how likely any difference in the results occurs by chance. Our alpha value is also the probability of a type I error, which is stating that two samples come from different populations, when in fact they do not. An asterisk, * denotes statistical significance where $P \leq 0.05$ which represents deviations exceeding 1.96 standard deviations, and is the standard value used. A statistically significant difference indicates that the two samples are different not by chance, but due to the fact that they come from different populations.

Section 4.2 Equivalency Tests for Classes

Pharmaceutical calculations (PHCH 517) is one of the first courses that students take when start pharmacy school at University of Kansas. Therefore, their performance in PHCH 517 is likely based upon their background when they enter pharmacy school. A study by Kuncel et al (2005) showed that PCAT scores and preRx-GPA were positively correlated with first-year GPA

in pharmacy school, and were moderate to strong predictors of grades earned in pharmacy school.

In order to determine if the three classes were generally equivalent in preparation and knowledge coming into the class, two preadmission characteristics were examined for statistically significant differences. The preadmission averages for pre-Rx cumulative GPA and PCAT composite score for the three classes are shown in Table 4-1.

Class	*Criteria*	*Mean*	*N*	*Std. Deviation*
2009	GPA	3.59	87	0.29
	PCAT	79.10	83	13.42
2012	GPA	3.65	105	0.30
	PCAT	75.75	105	14.57
2013	GPA	3.54	106	0.36
	PCAT	75.68	106	14.50

Table 4-1: Mean Scores for PreRxGPA and Composite PCAT Score Across Classes

For the class of 2009, numbers for each metric (GPA and PCAT) are different due to incomplete records (preRx-GPA's were not available or PCAT comprehensive scores were not

available). We can see the class of 2012 had the highest average GPA of the three classes. The class of 2013 had the lowest PCAT composite score of the three classes. The average PCAT score of all test takers in the United States is 50%. The average PCAT score of successful applicants in the United States is 69%, according to www.uspharmd.com. As was noted previously, the PCAT changed both format in June 2007 and the groups that students were compared to. These changes resulted in a slight decrease nationally in test scores for successful applicants. This was seen at KU SOP as well.

When comparing the means of more than two groups, a one-way ANOVA (analysis of variance), is the most typical statistical analysis educational researchers will use. In order to use a one-way ANOVA, data must be normally distributed (Bell curve or Gaussian distribution). A researcher will typically do some exploratory analysis before running any statistical tests, including testing for normal distribution of the data. Because there were three groups or classes of students to compare, exploratory analysis was done to determine the appropriate statistical test.

Shapiro-Wilk W Test is used to test for non-normality in small to medium sized samples (3 – 5000)(Conover 1999; Shapiro and Wilk 1965). The sample is compared to a normally distributed population with the same mean and standard deviation to see the goodness of fit to this normal distribution. The null hypothesis is that the sample data comes from a normally distributed population.

The test statistic for Shapiro-Wilk is:

$$W = \frac{\left(\sum_{i=1}^{n} a_i x_{(i)}\right)^2 \left(\sum_{i=1}^{n} a_i x_{(i)}\right)}{\sum_{i=1}^{n} (x_i - \overline{x})^2} \text{ where}$$

- x_i is the ith order statistic

- $\bar{x} = (x_1 + \ldots + x_n)/n$ is the sample mean
- The constants a_i are given by

$$(a_i, \ldots, a_i) = \frac{m^T V^{-1}}{(m^T V^{-1} V^{-1})^{1/2}}$$

where

$m = (m_1, \ldots, m_n)^T$

And $m_1, \ldots, m_n$ are the expected values of order statistics of the independent and identically-distributed random variables samples from the standard normal distribution, and V is the covariance matrix of those order statistics.

The test statistic W is compared to expected values (which are generated based on sample size and degrees of freedom) and a p value is generated.

Shapiro-Wilk analysis of preRxGPA and PCAT composite scores was run in SPSS for the three classes. P values as shown in Table 4-2, which indicate the probability that these groups fit a normal distribution, all came back as less than 0.05, meaning that the distribution of mean scores for preRxGPA and composite PCAT scores were significantly different from a normal distribution. This would indicate that a one-way ANOVA of the data is not the most appropriate statistical test for this data.

		Shapiro-Wilk		
	Class	*W Statistic*	*df (degrees of freedom)*	*P (significance)*
PreRxGPA	2009	0.948	82	**0.002***
	2012	0.920	105	**0.000***
	2013	0.945	106	**0.000***
PCATComp	2009	0.951	82	**0.003***
	2012	0.943	105	**0.000***
	2013	0.969	106	**0.014***

Table 4-2: Tests for Normality; PreRxGPA and PCAT Composite Across Classes

Visual examination of PCAT score frequencies for the class of 2013 shows the distribution more clearly (Figure 4-1). In contrast to a Gaussian distribution, the data are heavily weighted towards the higher scores and does not decrease evenly on both sides of the average score.

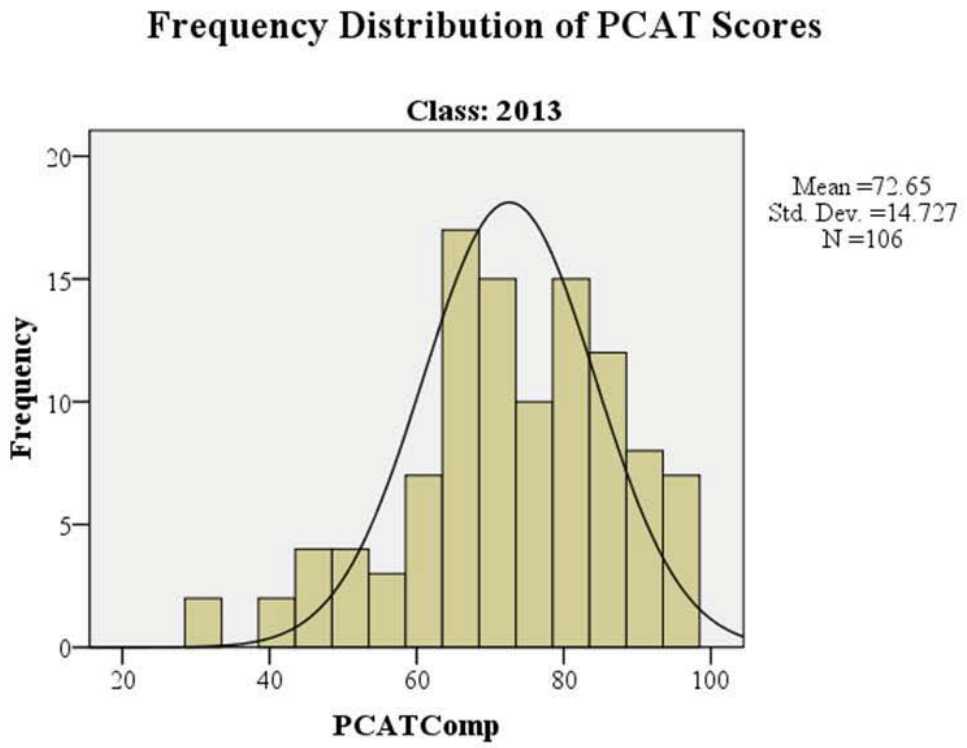

Figure 4-1: PCAT Score Frequencies of Class of 2013

Because these analyses demonstrated that both preRx-GPA and PCAT composite scores were not normally distributed, Kruskal-Wallis H, the nonparametric test for variance in more than two groups, was done to compare the three samples. Kruskal-Wallis is most commonly used when there is one nominal variable (in this case, the class year from which the data were collected) and one measurement variable which does not meet the normality assumption.

In the Kruskal-Wallis data analysis, data are replaced by rank order. All data from all groups are ranked ignoring the group they came from. Any values that are the same are given the average of the ranks for that value. An example for this data set is shown in Table 4-3.

Grade	Class	Rank	Average
C	2009	1	15/5 = 3
C	2012	2	15/5 = 3
C	2012	3	15/5 = 3
C	2012	4	15/5 = 3
C	2013	5	15/5 = 3
B	2009	6	30/4 = 7.5
B	2013	7	30/4 = 7.5
B	2013	8	30/4 = 7.5
B	2013	9	30/4 = 7.5
A	2009	10	91/7 = 13
A	2009	11	91/7 = 13
A	2012	12	91/7 = 13
A	2012	13	91/7 = 13
A	2012	14	91/7 = 13
A	2013	15	91/7 = 13
A	2013	16	91/7 = 13

Table 4-3: Rank Order Example

The test statistic for Kruskal-Wallis is given by:

- $K = (N-1)\frac{\sum_{i=1}^{g} n_i(\bar{r}_i - \bar{r})^2}{\sum_{i=1}^{g}\sum_{j=1}^{n_i}(r_{ij} - \bar{r})^2}$ *where:*

- n_i *is the number of observations in group i*

- r_{ij} is the rank (for all observations) of observation j from group i

- N is the total number of observations across all groups

- $\bar{r}_i = \frac{\sum_{j=1}^{n_i} r_{ij}}{n_i}$
- $\bar{r} = \frac{1}{2}(N+1)$ is the average of all the r_{ij}

A correction for equivalent values can be made by dividing the K statistic by:

$1 - \frac{\sum_{i=1}^{G}(t_i^3 - t_i)}{N^3 - N}$ where G is the number of groupings of different equivalent value ranks, and t_i is the number of equivalent values within group *i* that are the same at a particular value. This correction is usually not needed and does not make a difference in K unless there are a large number of equivalent values.

A p-value is approximated by Pr ($\chi^2_{g-1} \geq K$) where χ^2 (chi-squared) is the probability distribution with g-1 degrees of freedom (df) and is used to determine whether distributions of categorical variables differ from each other. Our categorical variable in this case is class, . Because Kruskal – Wallis does not assume a normal distribution, it is considered a more robust test than one way ANOVA. Kruskal-Wallis can also be described as an ANOVA by ranks.

The three classes were compared by Kruskall-Wallis analysis for preRxGPA and there was not a significant difference across the three samples (p=0.095) as shown in Table 4-4.

Kruskal-Wallis H				
Class	N	Mean Rank	Results	
2009	87	145.90	χ^2	4.705
2012	105	163.60	df	2
2013	106	138.48	p	0.095
Total	298			

Table 4-4: Kruskal-Wallis H for PreRxGPA Across Classes

From this analysis, we can surmise that the three classes are approximately equal in preparation coming into PHCH 517 based on preRx-GPA. This result is not surprising as we would expect that successful applicants at the same school to have approximately the same metrics unless a major change in admission criteria is initiated.

Kruskal-Wallis analysis of PCAT composite score across the three classes was computed (Table 4-5). The test showed there was statistically significant difference ($p = 0.010$) between

the three classes. As was mentioned previously, the format of the PCAT examination changed significantly in 2008, and average scores changed significantly as well.

Kruskal-Wallis H				
Class	N	Mean Rank	Results	
2009	83	167.27	χ^2	9.150
2012	105	149.72	df	2
2013	106	129.82	p	**0.010***
Total	294			

Table 4-5: Kruskal-Wallis H for PCATComp Across Classes

The class of 2009 took the previous test and the classes of 2012 and 2013 took the newer version of the PCAT. The statistical difference that was significant in PCAT composite scores could reasonably be attributed to the difference in exam format. To see if there is a statistically significant difference in PCAT scores for the classes of 2012 and 2013, who took the same exam format. the Mann-Whitney test is used. The analysis for two groups with a non-normal distribution is a Mann-Whitney test, which is essentially the same as a student's t-test (used to

compare the means of two normal distributions). The Mann-Whitney test is also known as the Wicoxon rank-sum test as the data are ranked just like in the Kruskal-Wallis Test. Our null hypothesis is that there is no difference in average of the two samples. Table 4-6 shows the results of this analysis. When we compare only the classes of 2012 and 2013 in reference to the PCAT composite score, p is not significant (0.091). This would indicate that there is no difference in the means of the PCAT composite score between the classes of 2012 and 2013, and therefore, they are comparable in terms of their content knowledge based on PCAT composite scores.

Mann-Whitney U

Class	*N*	*Mean Rank*	*Test Statistic*	*Results*
2012	105	111.04	U	5036
2013	106	101.00	Z (Std. devs)	-1.69
Total	211		p	0.091

Table 4-6: Mann-Whitney U for Classes of 2012 and 2013

A study by Granberry and Stiegler (2003) examined the preRx-GPA and PCAT composite scores of students at the University of Arkansas over a 20 year period from 1982 – 2002 and found there was no change in preprofessional GPA's or PCAT composite scores over the study period. Although there was a statistically significant change in PCAT scores between the class of 2009 and the classes of 2012 and 2013, there was not a statistically significant difference in preRx-GPA's. It is a reasonable assumption that the three classes are comparable in terms of class readiness.

Section 4.3 Grade Distribution

As was mentioned previously, virtually all students are successful at passing PHCH 517 with a C or greater. More than half of the class receives an A. In fact, when comparing final student outcomes of the three classes, it is apparent that the grade distribution is negatively skewed (left skewed) for all three classes (Figure 4-2).

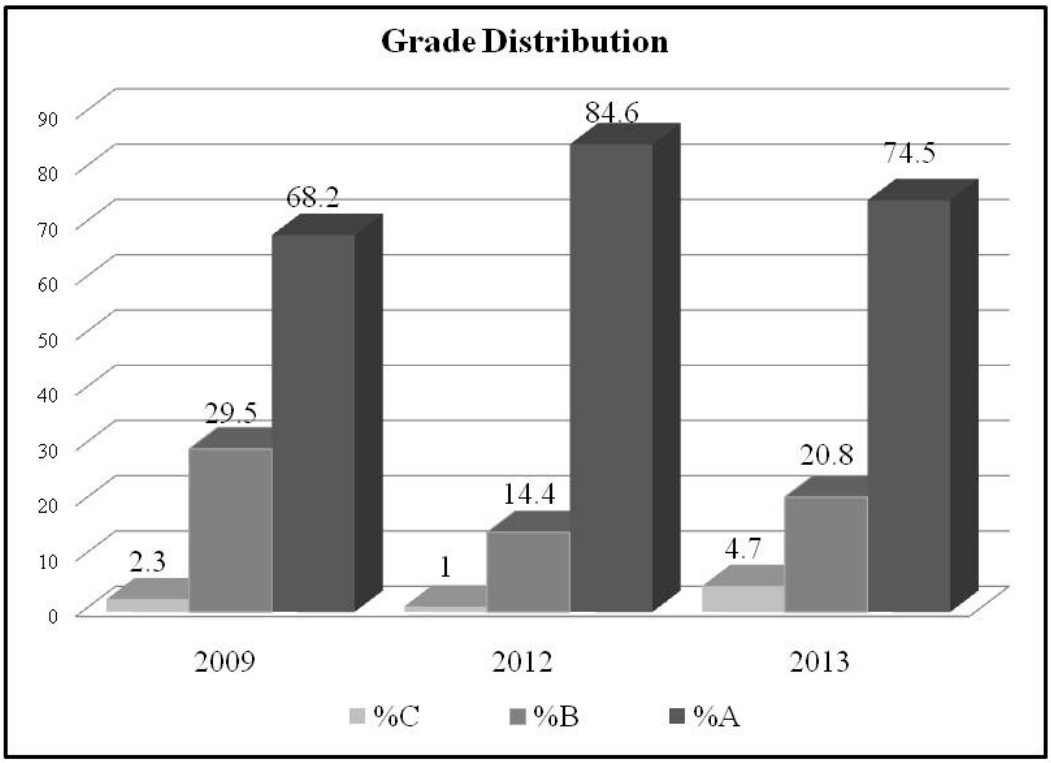

Figure 4-2: Grade Distribution across Classes

Because the data are so negatively skewed (or left skewed), the normalcy of final student outcomes was assessed using the Shapiro-Wilk test. Confirmed by Table 4-7, the null hypothesis is rejected that the data are normally distributed for each class.

		Shapiro-Wilk		
	Class	W Statistic	df (degrees of freedom)	p (Significance)
Final Score	2009	0.626	88	**0.000***
	2012	0.405	105	**0.000***
	2013	0.577	106	**0.000***

Table 4-7: Tests of Normality Across Classes

Because the distribution of grades is not normal for any of the classes, Kruskal-Wallis must be used to compare the final grades and assess if there is any difference in outcomes.

Section 4.4 Data Analysis for Final Outcomes Across Classes

Our first research question, which asks whether student outcomes for BL will be comparable to F2F, can be answered by looking at final grade outcomes from each class (which is the delivery format). Comparison of all three classes shows a statistically significant difference between the three classes (Table 4-8).

Kruskal-Wallis H

Class	*N*	*Mean Rank*	*Test Statistic*	*Results*
2009	88	139.06	χ^2	6.263
2012	105	161.80	df	2
2013	106	147.39	p	**0.044***
Total	299			

Table 4-8: Kruskal-Wallis H for Final Score Across Classes

This result only tells us that there is a statistically significant difference among the grade outcomes, but does not identify which classes show this difference. Additional analyses were done comparing just two classes at a time. The nonparametric Mann-Whitney test was conducted, comparing the following groups: Class of 2009 with 2012 (Table 4-9), Class of 2009 with 2013 (Table 4-10), and finally, Class of 2012 with 2013 (Table 4-11).

Mann-Whitney U

Class	*N*	*Mean Rank*	*Test Statistic*	*Results*
2009	88	88.93	U	3510
2012	105	103.76	Z (Std. devs)	-2.5
Total	193		p	**0.012** *

Table 4-9: Mann-Whitney U for Class of 2009 and 2012

Mann-Whitney U

Class	*N*	*Mean Rank*	*Test Statistic*	*Results*
2009	88	94.63	U	4411
2013	106	99.89	Z (Std. devs)	-0.827
Total	194		p	0.408

Table 4-10: Mann-Whitney U for Class of 2009 and 2013

Mann-Whitney U

Class	*N*	*Mean Rank*	*Test Statistic*	*Results*
2012	105	111.04	U	0.091
2013	106	101.00	Z (Std. devs)	-1.691
Total	211		p	0.091

Table 4-11: Mann-Whitney U for Class of 2012 and 2013

The only test that showed a statistical significantly difference was for the classes of 2009 and 2012 ($p = 0.012$, both F2F). There was not a statistical difference in final scores for the comparisons of the classes of 2009 with 2013 (F2F and BL), and 2012 with 2013 (F2F and BL). This means that although the Kruskal-Wallis analysis comparing the three groups came back as significant, it was due to the difference in the classes of 2009 and 2012, which were both F2F. The individual comparisons of the two F2F classes (2009 and 2012) with the BL class (2013) did

not show significant differences in final outcomes. This demonstrates that BL and F2F have comparable student outcomes for pharmaceutical calculations.

The Kruskall-Wallace H was additionally conducted for final score across all three classes dividing the groups by gender. For females, the result was not significant (Table 4-12, p = 0.100), indicating that final outcomes were comparable for females from all three classes.

Kruskal-Wallis H

Class	*N*	*Mean Rank*	*Test Statistic*	*Results*
2009	55	95.79	χ^2	4.615
2012	75	102.97	df	2
2013	61	87.61	p	0.100
Total	191			

Table 4-12: Kruskal-Wallis H for Final Score Across Classes for Females

Examination of Table 4-13 shows show the Kruskal-Wallis H for final score across classes for males is significant, p = 0.006.

Kruskal-Wallis H

Class	*N*	*Mean Rank*	*Test Statistic*	*Results*
2009	33	43.92	χ^2	10.172
2012	30	59.87	df	2
2013	45	58.68	p	**0.006***
Total	108			

Table 4-13: Kruskal-Wallis H for Final Score Across Classes for Males

Mann-Whitney analysis was run to compare the males of the classes of 2009 and 2012 (both F2F). This test shows there is a statistically significant difference between the groups, p = 0.010 (Table 4-14).

Mann-Whitney U

Class	*N*	*Mean Rank*	*Test Statistic*	*Results*
2009	33	43.92	U	349
2012	30	59.87	Z (Std. devs)	-2.56
Total	63		p	**0.010***

Table 4-14: Mann-Whitney U for Final Score for Males of Classes of 2009 and 2012

The same analysis of the males of the classes of 2012 and 2013 did not show a significant difference in final outcomes (Table 4-15).

Mann-Whitney U

Class	*N*	*Mean Rank*	*Test Statistic*	*Results*
2012	30	38.5	U	660
2013	45	37.7	Z (Std. devs)	-0.265
Total	75		p	0.791

Table 4-15: Mann-Whitney U for Final Score for Males of Classes of 2012 and 2013

This indicates that the statistically significant differences in final outcomes can be attributed to the males of the classes of 2009 and 2012, which were both F2F classes. Differences in final student outcomes in this study were not detected between the two class formats, F2F and BL, for either males or females.

Section 4.5 Survey of Student Attitudes

Students were invited to complete a survey at the beginning of the class. This was an anonymous survey collected via Blackboard (©2010). Students were informed that their participation in this study was voluntary. Their names and emails would not be associated with

the research findings. 85 students completed the initial class survey. Upon submitting the survey online, the results were stored on Blackboard. The researcher could manually retrieve the results at a later time.

The questions along with the averages are shown in Table 4-16.

	Question	5 = Strongly Agree, 1 = Strongly Disagree, 0 = Unanswered (Not counted) Pre-Class Survey Average N=85
1	I like the idea of online lectures.	3.14
2	I believe online lectures will help me to complete my homework questions.	3.20
3	The audio/video quality of the online lectures is adequate for my needs.	3.66
4	The online lectures will help me understand complex concepts.	3.24
5	I will use the online lectures to review for exams.	3.93
6	I prefer face-to-face lectures.	3.84
7	I hate math problems.	2.12
8	I like the online lectures because I can skip material I already understand.	3.32
9	The tutorials will be helpful to me to review material from the book/lectures.	3.82
10	I prefer to see my professor when he is talking.	3.60
11	I will spend more time studying the online lectures than I would with regular class notes.	2.89
12	I will learn more with online lectures than face-to-face lectures.	2.75
13	I would rather borrow notes from someone than use the online lectures.	2.15
14	I like to study in a group rather than alone.	3.00
15	I learn better from my professor than my peers.	3.00
16	I learn best alone.	3.55

Table 4-16 Student Attitude Survey Averages

The survey was taken from Cascaval (2008). Although the survey was not validated, the purpose was to ascertain student attitudes towards online lectures, online learning, group

learning, and face-to-face learning. An average of 3.00 would indicate an approximately neutral attitude towards these categories. Students seemed to be open towards using online lectures (Question 1, $\mu = 3.14$) but not overly enthusiastic. Based on question 5 ($\mu = 3.93$) and question 9 ($\mu = 3.82$), students seemed to view the online lectures and tutorials more as aids in learning, rather than the primary learning method. They seem to prefer to see their professor (Question 10, $\mu = 3.60$) although they acknowledge they may learn better alone (Question 16, $\mu = 3.55$). Zhao et al (2005) found that student's self assessment of learning in an online setting may in fact underestimate the amount of learning that takes place. Convincing students that learning may be taking place in a variety of settings, rather than just in a traditional classroom is not an easy task and may require an assortment of experiences over an extended period of time.

Section 4.6 Blackboard Access by Grade Distribution

The literature suggests that there is an inverse relationship between student's grades and time spent studying online material in an online course (Mayadas, Bourne, and Bacsich 2009). The Learning Management System Blackboard (©2010) allows an instructor to keep track of the number of times that a student logs on and accesses the course (Blackboard hits). This information is shown in Figure 4-3 .

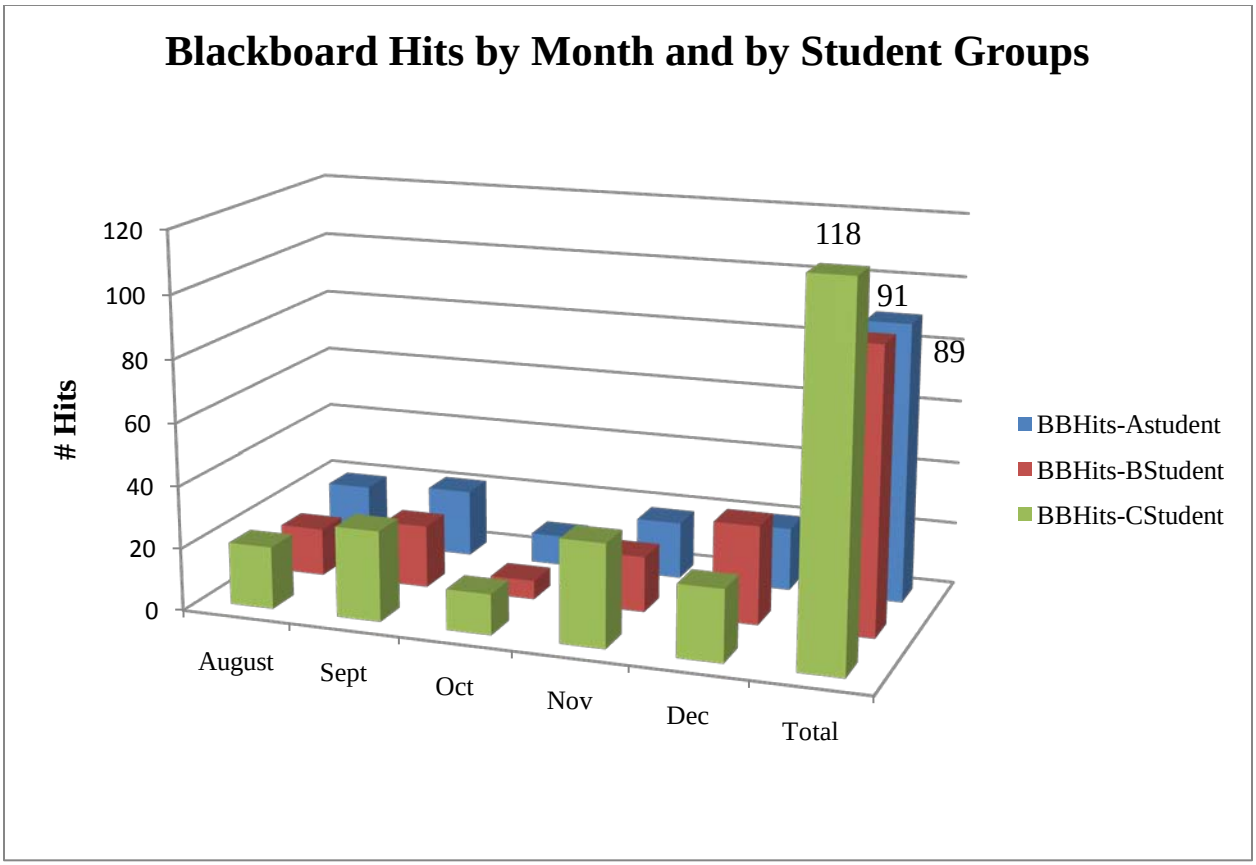

Figure 4-3: Blackboard Hits by Month and by Student Groups

One Way ANOVA indicated that there was not a statistically significant difference between the students grouped by grade ($p = 0.263$) although the data echoes what the literature has shown.

Chapter 5

Discussion

Section 5.1 Equivalency of Courses

Several questions need to be addressed in order to determine the effectiveness of blended learning in pharmaceutical calculations. It should first be shown that these classes are comparable in terms of student's course readiness. This is assessed from the student's pre-pharmacy GPA and PCAT composite scores. The mean scores for pre-pharmacy GPA for the three classes are: 2009, 3.59; 2012, 3.65; and 2013, 3.54 (Table 3-1). Pre-pharmacy GPA, which is a measure of all classes taken prior to entry into pharmacy school, and is measured over a wide variety of classes and over a period of time, is a fair indicator of preparatory work prior to entrance to pharmacy school and is used universally to determine entrance into pharmacy schools (McCall, Allen, and Fike 2006). Because the data were not normally distributed, the nonparametric test, Kruskall-Wallis was used to determine if there was a significant difference between the three classes for preRx GPA. As was shown in Table 4-4, there was no significant difference between these classes ($p = 0.095$) when examining preRx GPA. This would be one indicator that each class had approximately equal course readiness coming into the class.

PCAT scores are used in addition to preRx GPA to determine an applicant's readiness for pharmacy school (Duncan-Hewitt 1996; Thomas and Draugalis 2002; Munson and Bourne 1976; Friedman et al. 1987; Allen and Bond 2001). Although controversy exists over the use of standardized exams, the majority of pharmacy schools in the United States use them to compare candidates. The three classes mean scores (percentile) for the PCAT composite score are: 2009, 79.10; 2012, 75.75; and 2013, 72.65 (Table 3-1). The format of the PCAT exam changed significantly between when the class of 2009 took the exam, and when the classes of 2012 and 2013 took the exam. After determining that the data were not normally distributed, Kruskall-Wallis H was used to determine if there was a significant difference between the three classes for

PCAT composite score. As shown in Table 4-5, there is a statistically significant difference between the classes ($p = 0.010$). The scores decreased from the class of 2009 to the classes of 2012 and 2013, which was a trend that was seen nationally as well. When the classes of 2012 and 2013 were compared to each other as shown in Table 4-6, there was no statistical difference in PCAT composite scores.

Even though the PCAT composite scores for the three classes did show a statistically significant difference, the preRx GPA's did not. Because the class of 2009 was taught by a different instructor and would therefore be a good comparison group, and also because the pre-Rx GPA's were comparable to the other two classes, the final scores of the three classes were used in comparisons of the classes.

Section 5.2 Grade Distribution

In general, all students are successful at completing and passing pharmaceutical calculations at KU SOP with minor exceptions. As was mentioned previously, the math skills used in this class are not advanced, so the fact that the majority of students not only pass this class, but pass with an A, is not surprising. The final grade distribution of the three classes was analyzed and found to not fit a normal distribution. Figure 4-2: Grade Distribution across Classes, shows final grade outcomes for the three classes. The class of 2009 had 68% of the class pass with an A, the class of 2012 had 85% pass with an A, and the class of 2013 had 75% of the class pass with an A. The classes of 2009 and 2012 used the same textbook (Ansel and Stoklasa 2005). The class of 2013 used the same textbook, but a newer edition (Ansel 2009). The coverage of material remained the same for all three classes. Because the same textbook was used and the same material was covered, final grades reflect mastery of the same course content.

As was shown in Table 4-8, there is a statistically significant difference in final scores when comparing the three classes, ($p = 0.044$). Additional analyses were done to ascertain the source of the differences between the classes. The nonparametric t-test, Mann Whitney U, was done to compare the final score for the following groups; Class of 2009 and 2012, Class of 2009 and 2013, and finally Class of 2012 and 2013. Table 4-9, Table 4-10, and Table 4-11, show the results of these comparisons. There was only a statistically significant difference when the classes of 2009 and 2012 were compared to each other, ($p = 0.012$). These were the two F2F classes. The comparison of these two classes with the class of 2013, which was the BL class, did not show a significant difference in final outcomes.

Further analysis to compare the three classes was done by separating by gender. For females in all three classes, there was not a significant difference in final outcomes (Table 4-12). For males in all three classes, there was a statistically significant difference as show in Table 4-13. When comparing the males of the two F2F classes, as shown in Table 4-14, there is a statistically significant difference between the classes of 2009 and 2012 ($p = 0.010$). The same test for males in the classes of 2012 and 2013 was not significant. This means that the statistically significant difference between the three classes can be attributed to the difference between the males of the classes of 2009 and 2012, which were both F2F. There was no difference in final outcomes between F2F and BL classes for either males or females. F2F and BL had comparable student outcomes.

Section 5.3 Results

The first research question for this study was whether BL as a class format was as effective at teaching course content as F2F. There was no difference in final student outcomes between either F2F class (2009 and 2012) and the BL class (2013). Additionally, there was no

difference between either males or females when comparing the F2F classes and the BL class. The only difference that was seen was between the males of the two F2F classes (2009 and 2012). Carroll and Garavalia (2002) found no gender differences in self-regulated learning strategies or motivation levels in pharmacy students. In addition, no differences were observed in student success across gender. The difference in final outcomes that was seen in this study cannot be attributed to class format.

Although there were gender differences for males but not for females in final outcomes in this research study, they were not shown in the comparison of BL with F2F. The significant difference that was shown for males in the classes of 2009 and 2012 is an interesting note, but cannot be attributed to online learning differences, as both of these classes were F2F (different instructors). There are no observations in the literature of gender differences for student success in pharmacy school to date. Student success in pharmacy school is assessed over a variety of courses. The difference in final outcomes would need to be shown over several courses using both teaching formats before a pattern of gender difference can be demonstrated.

The survey of student attitudes was used to assess if students were going to be particularly biased against this new course format. Overall, the students that were surveyed were willing to try the new class format, but not overly keen to do so. These attitudes are not surprising given that probably very few of the students had ever had a blended learning class format. Class changes need to be demonstrated over a period of time for both students and faculty.

Overall, the efficaciousness of blended learning in an introductory pharmacy class was demonstrated. This result is significant due to the fact that this has not been demonstrated in the literature previous to this study. In order for blended learning to be implemented in more

courses, it must first be demonstrated that student outcomes are comparable and this study has demonstrated that. Further research in other didactic courses in the pharmacy curriculum is certainly warranted.

In order for BL to be successful in the future, the college or university needs to be prepared to support the change. Recommendations for this would include providing the necessary technology training for both students and faculty. In addition, requiring that those participants have the necessary technology available such as hardware, software, and network digital bandwidth is essential. Many pharmacy schools, such as the University of Kentucky College of Pharmacy, are requiring that admitted students have laptop computers with certain specifications and must bring them to class daily (http://pharmacy.mc.uky.edu/depts/it/mobile.php, accessed March 24, 2010). In addition, their new college of pharmacy building was designed to accommodate high-speed wireless computing throughout the structure.

As KU SOP increases its class size while facing budget challenges, the advantages of being able to reuse a course from year to year certainly should be appealing to faculty and administrators. In order to offer the advantages to those students who would most benefit from it, the course could be offered on a voluntary basis to incoming students in the summer prior to pharmacy school for example. BL would also be an easy way to incorporate those students who are learning at a satellite location. Students who would prefer a F2F class format, could take it in person during their first semester of pharmacy school. Being able to pick and choose a class format, that is most beneficial to a student, has appeal for today's consumer-oriented learners. Being able to offer a quality course to students at a variety of locations and schedules is certainly

a benefit to administrators. It remains to be seen by students, faculty, and administration what the optimum "blend" in learning would be for today and in the future.

No significant difference, which is what has been shown in the past for the comparison of online learning and F2F class format in a wide variety of classes, was also the conclusion here. What is notable in this case is that this result was for the comparison of BL and F2F, which has not been shown before in a pharmacy setting for an introductory course. Demonstrating that BL is effective at teaching course content is the first step in the shift towards making BL a viable and successful course format. BL is more than a delivery technology, it is a new way to design course content and a new way to facilitate learning (Bonk and Graham 2006). Although a significant amount of resources are necessary when transforming a course from a traditional F2F course to a BL course, this learning curve is surmountable with the right support and motivation. The support can be in the form of technology resources and innovation happening on many college campuses. The motivation can come from creating more effective learning experiences for students that increase access while reducing costs. As more research studies demonstrate the efficacy of BL, the promises of BL can come to fruition. "…In the future, learning will become a competitive differentiator separating those organizations that are merely surviving from those that are leaders in the knowledge economy." (Bonk and Graham 2006). The mission of KU SOP is "to provide exceptional opportunities for professional . . . students . . . through exemplary curricula and programs" (http://www.pharmacy.ku.edu/index.php?page=content:deans_welcome, accessed March 24, 2010). Through continued research on BL in a pharmacy setting, and hopefully, continued efficacy, the hope is that BL proves to be an exceptional opportunity for professional students now and in the future at KU SOP, as well as other pharmacy schools in the United States.

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Appendices

Appendix A: Syllabus for Pharmaceutical Calculations from Fall 2009

PHCH 517
PHARMACY CALCULATIONS
Fall 2009

Tuesdays and Thursdays, 3:00 to 3:50 pm, Room 2001 Malott

Instructor: Dr. Eric Munson, 236A Simons Laboratories. Phone:864-3319, e-mail: munson@ku.edu
Office Hours: By appt.

Teaching Assistant: Christina Munson, Malott 1030, Phone:864-3113, e-mail: munson2@ku.edu
Office Hours: By appt.

Course Objective and Outcomes: Upon completion of this course, the successful student will be able to do the following:

- ✓ Understand the basics of pharmaceutical calculations and measurement
- ✓ Perform mathematical manipulations utilizing different expressions of concentration
- ✓ Differentiate the written parts of a prescription

In addition, the student will be able to perform pharmaceutical calculations with consistency and minimal error.

Required Text: *Pharmaceutical Calculations, 13th Ed.*, H. Ansel. Lippincott, Williams & Wilkins, Philadelphia, 2008. Available at KU bookstore.

Supplemental Material: CPS Clicker by e-instruction, 2nd generation only, available at KU bookstore.

Class Format: Lectures and Tutorials will be administered via Blackboard. Class time will be devoted to problem sessions and hour exams (see Lecture Schedule). Students are expected to bring their CPS transmitter ("clicker") to every class session. Your responses to in-class questions will be recorded and may be considered part of your grade. For this reason, anyone who brings more than one transmitter to class may be charged with academic misconduct, along with the owner of the "extra" clicker. Such behavior is the equivalent of cheating on a test and will not be tolerated.

Homework: Each student should do as many homework problems from the assigned chapters as possible. No credit will be given for homework turned in late. It is recommended that you retain a photocopy of your homework for study purposes. The homework set will be graded as either complete or incomplete. Credit for the homework from that set will be given if SUBSTANTIAL work is shown for EACH problem in the set. Exam questions will be taken from the homework and worksheets.

Tutorials: The tutorials are self-paced and meant to review and refresh the material. You may access and complete the tutorials as many times as you like. The tutorials are meant to be done BEFORE the class where problems are worked on that material. A suggested schedule is included in the syllabus schedule.

Homework sets (Practice problems):

Set #1	Chapter #1 Chapter #2	3,6,12,17,18,19,20,25 (pp 11-12) 3,8,16,22,29,35,44,47,50	Due August 27th
Set #2	Chapter #3 Chapter #4 Appendix A	2,4,6,8,10,12,16 1,2,3,5 1,3,5,14,17,18,25	Due September 3
Set #3	Chapter 5	1,3,6,8,9,11,12,14,17,20,22,25,26, 30,32,34	Due September 10
Set #4	Chapter 6	3,7,9,14,17,20,23,25,28,32,38,41, 44,47,49,60,64,70	Due September 24
Set #5	Chapter 7 Chapter 8	2,6,11,12,23,27,31,32 1,6,12,17,26,33,36,41,52	Due October 1
Set #6	Chapter 9 Chapter 10	1,6,9,10,12,16,24 1,6,7,9,12,15,17,19	Due October 13
Set #7	Chapter 11 Chapter 12	1,5,8,10,14,17,20,25,30,36 1,7,11,15,20,27,32,41,47	Due October 29
Set #8	Chapter 13	1,5,7,10,13,16,19,21,23,25,28,31, 33,39,43	Due November 10
Set #9	Chapter 15	2,5,7,9,10,12,18,19,24,25,29,31,3 4,37,39,42,46,47,50,55,57,60,65,6 7,68,71	Due November 19
Set #10	Chapter 16 Chapter 22	Even Problems Odd Problems	Due December 3

Exams: There will be three in-class midterm exams, consisting of approximately ten problems each. You will be allowed one 3 x 5 Index Card with anything written on it for the exam – for example: formulas, conversions, worked problems. Exam problems will be taken from the text and from the homework. There will be two online exams. There will also be a final exam, worth two one-hour exams. For an exam problem to be considered correct, the numerical answer must be within 5% of the instructor's result. NO PARTIAL CREDIT WILL BE GIVEN for correct methods with incorrect results.

Course Grades: Students whose average grade going into the final is 95% or higher on the in-class exams and who meet the "A" criteria for homework and worksheets are exempted from taking the Final Exam and will receive an "A" for the course.
In addition, the grade breakdown is as follows:

Homework	40 points
Worksheets (Clicker Sessions)	30 points
Tutorials	30 points
Two Online Exams (50 points each)	100 points
Three Midterm Exams (100 points each)	300 points
Final Exam	200 points

PHCH 517 SCHEDULE FALL 2009				
Date	**Topic**	**In-class activity**	**Text Chapters**	**What's Due/Out-of-Class Activities**
8/20 (R)	Introduction	Course Format	Chapters 1,2	Lecture #1 Available via Blackboard Tutorials: Fractions, SI Units
8/25 (T)	Introduction to measurement and calculation	Worksheet #1 CPS	Chapters 1, 2	BRING CLICKER! Tutorials: Dimensional Analysis, Exponential Notation
8/27 (R)		Q/A	1, 2	**Homework set #1 Due**
9/1 (T)	Interpretation of prescriptions, systems of units, conversions	Worksheet #2 CPS	Chapters 3, 4 Appendix A	Lecture #2 Available via Blackboard Memorize the abbreviations on pp. 60-61 and the Rx components in Fig. 4.1 (p. 55).
9/3 (R)		Q/A	3, 4 Appendix A	**Homework set #2 Due**
9/8 (T)	Density, sp. gravity and sp. volume	Worksheet #3 CPS	Chapter 5	Lecture #3 Available via Blackboard Tutorials: Measurement,Density
	***ONLINE EXAM #1(Chapters 1 – 5)* Available from 9/8 4:00 pm until 9/15 3:00 pm**			
9/10 (R)		Q/A	5	**Homework set #3 Due**
9/15 (T)	Percentage and ratio strength calculations	Worksheet #4 CPS	Chapter 5	Lecture #4 Available Online Tutorials: Concentration
	ONLINE EXAM #1 Due			
9/17(R)		Worksheet #5 CPS	Chaps. 6	Lecture #5 Available Online
9/22 (T)		Q/A		**Homework set #4 Due**
9/24 (R)	Dose calculations	Worksheet	Chaps. 7,	Lecture #6 Available

PHCH 517 SCHEDULE FALL 2009				
Date	**Topic**	**In-class activity**	**Text Chapters**	**What's Due/Out-of-Class Activities**
		#6 CPS	8	Online Tutorials: Dose Calculations
9/29 (T)		Q/A	Chaps. 7, 8	**Homework set #5 Due**
10/1(R)	***MIDTERM EXAM #1*** **(Chapters 5 – 8) IN-CLASS (BRING CLICKER)**			
10/6 (T)	**No Class**			
10/8 (R)	Units, clinical calculations	Worksheet #7 CPS	Chaps. 9-10	Lecture #7 Available Online Tutorials: Potency, Clinical Calculations
10/13(T)		Q/A		**Homework set #6 Due**
10/15 (R)	**No Class Fall Break**			
10/20 (T)	Isotonic and buffer	Worksheet #8 CPS	Chapter 11	Lecture #8 Available Online Tutorials: Buffers
10/22 (R)		Q/A		
10/27 (T)	Electrolyte Solutions	Worksheet #9 CPS	Chapter 12	Lecture #9 Available Online Tutorials: Tonicity
10/29 (R)		Q/A		**Homework set #7 Due**
11/3(T)	***MIDTERM EXAM #2*** **(Chapters 9-12) IN-CLASS (BRING CLICKER)**			
11/5 (R)	IV infusions	Worksheet #10 CPS	**Chapter 13**	Lecture #10 Available Online Tutorials: Nutrition
11/10(T)			Q/A	**Homework set #8 Due**
11/12 (R)	Dilution I	Worksheet #11 CPS	Chapter 15	Lecture #11 Available Online Tutorials: Alligation, Dilution, Millimoles
11/17 (T)	Dilution II	Worksheet #12 CPS	Chapter 15	
11/19 (R)		Q/A		**Homework set #9 Due**
	ONLINE EXAM #2(Chapters 13,15) **Available from 11/19 4:00 pm until 11/24 3:00 pm**			
11/24(T)	Reducing/Enlarging Formulas	Worksheet #13	Chapter 16	Lecture #12 Available Online

PHCH 517 SCHEDULE FALL 2009				
Date	**Topic**	**In-class activity**	**Text Chapters**	**What's Due/Out-of-Class Activities**
		CPS		
	ONLINE EXAM #2 Due			
11/26(R)	**No Class Thanksgiving Break**			
12/1 (T)	Introduction to bioavailability, pharmacokinetics	Worksheet #14 CPS	Chapter 22	Lecture #13 Available Online Tutorials: Bioavailability and Pharmacokinetics
12/3 (R)		Q/A		**Homework set #10 Due**
12/8 (T)	***MIDTERM EXAM #3*** **(Chapters 15,16,22) IN-CLASS (BRING CLICKER)**			
12/10(R)	Review/Evaluations			
12/18 (F)	**Final Exam Friday December 18th 1:30 – 4:00 pm**			

PHCH 517

PHARMACY CALCUATIONS
Homework

General Policy: Students who perform well in this course have, in most cases, done almost all of the problems in the assigned sections of the textbook. You are strongly encouraged to work as many of these problems as possible.

Getting Help: In some cases, you may find the problems in the textbook difficult to solve, particularly later in the course. If this occurs, you are encouraged to seek help in one or more of the ways listed below.

1) Attend Class: Many of the questions that you have will be addressed in the lecture or problem sessions. Plan to attend class, particularly if you're having problems with the homework. *The instructor and teaching assistants reserve the right to refuse to answer questions for students who have not attended class.*

2) Check Blackboard Website: The instructor will post answers to homework problems on the blackboard website for the course. Instructions for accessing the website will be presented in class.

3) Visit the Instructor During Office Hours: If requested, the instructor will schedule weekly office hours in Malott at a time compatible with your class schedule. Office hours provide you with an opportunity to ask questions of the instructor in a one-on-one or small group setting.

4) Attend Review Sessions: At least one review session will be held before each exam, and for some exams, multiple review sessions. This is the best chance for you to see what problems other students are having, and to have your individual questions answered by the instructor outside of class.

5) Schedule an Individual Meeting with the Instructor: If you have general concerns about the course or about your performance, you should schedule an individual meeting with the instructor.

NOTE: *The instructor will not answer questions regarding homework or exam problems by telephone or e-mail. Plan ahead so that you can ask your questions during class or during office hours.*

PHCH 517
PHARMACY CALCULATIONS

Contract for Professional Behavior

By your enrollment in this class, you agree to meet the expectations for professional behavior that are listed below. The individual expectations can be summarized in this statement:

You will demonstrate respect for your classmates, for the teaching assistants, and for the instructor.

In return, the instructor and teaching assistants will treat you and your classmates with respect, fairness and courtesy, and will do their best to present the course material with accuracy and clarity.

Expectations for Professional Behavior:

1) Class Attendance: Attendance at lectures and problem sessions is required. However, individualized help may not be provided to those who miss class. Attendance at all exams is mandatory. If you will miss an exam for health reasons, you must contact the instructor before the scheduled exam time. The instructor may ask you to provide a written doctor's excuse before scheduling a make-up exam.

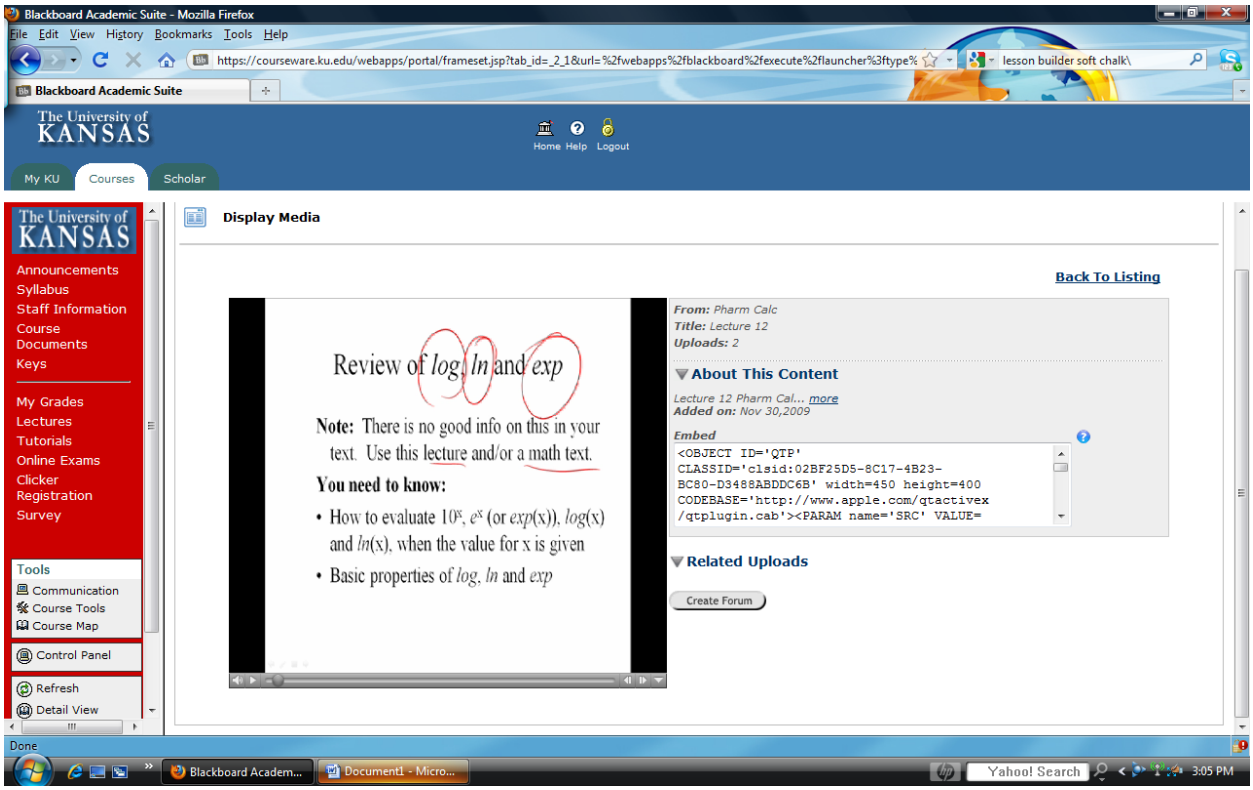
2) Tardiness: If you do attend class, it is expected that you will arrive on time and remain until the end of the class period.

3) Talking: Excessive talking during lectures is discouraged because it interferes with learning for other students. If you must communicate briefly with a classmate, please pass a note. If you must conduct an extended conversation, please skip the class and hold your conversation elsewhere. The instructor will ask students who disrupt the class to leave the room.

4) Exam Grades: After a graded exam has been returned to you, you may feel that one or more of the problems has been graded incorrectly or unfairly. If so, you may "appeal" your grade. To appeal, you must attach a written explanation of your concern to your exam and turn it in to the instructor. You must do this within one week of the time your graded exam is returned to you. The instructor will review your explanation, re-grade the exam if warranted, and return the exam to you with any grade change noted. The instructor's decision is final.

5) Cheating: You will not cheat on the exams. If an instructor or teaching assistant suspects that you are cheating, you may be asked to take the exam at another time or in another room. If cheating on an exam can be documented, you will receive an automatic grade of "F" for the course.

Appendix B: Sample Screen Shot From Online Lecture



Appendix C: Sample In-Class Worksheet

Pharmaceutical Chemistry 517

KEY

Worksheet #1 Form A

1)Round this number to three significant figures:

200.59 Answer:201; 200.? Greater than or equal to 5, round up

2) How many zeroes are significant in this number?

0.002030450600 Answer:5; highlighted zeroes are significant, leading zeroes are not

0.00203045060**0**

3) How many significant figures are in the following number?

0.0049400 Answer:5, see above for reasoning

4) Do the following calculation and report your answer to the correct significant digits:

(200.34 + 1018)/2984.45 = 0.4082 or 0.4081 are acceptable, answer should be 4 sig figs

5) A penicillin V potassium preparation provides 400,000 units of activity in each 250 mg tablet. How many total units of activity would a patient receive from taking four tablets a day for 10 days?

400,000 units/1 tablet x 4 tablets/1 day x 10 days = 16,000,000

6) A formula for 250 tablets contains 1.5 grams of diazepam. How many grams of diazepam should be used in preparing 50 tablets?

1.5 grams/250 tablets x 50 tablets = 0.3 grams

7) A prescription drug cost the pharmacist $225 for a bottle of 300 tablets. What would be the cost for 30 tablets?

$225/300 tablets x 30 tablets = $22.50

8) If an injectable solution contains 15 mcg of a drug substance in each 0.5 mL, how many mL would be required to provide a patient with 0.15 mg of the drug?

0.15 mg x 1000 mcg/1 mg x 0.5 mL/15 mcg = 5 mL

9) A liquid oral concentrate of morphine sulfate contains 5.0 g of morphine sulfate in a 250 mL bottle. Calculate the concentration of morphine sulfate on a mg/mL basis.

5.0 g x 1000 mg/1 g x 1/250 mL = 20 mg/mL

10) Prochlorperazine (COMPAZINE) for injection is available in 10-mL multiple dose vials containing 5 mg/mL. How many 5 mg doses can be withdrawn from the vial?

5 mg = 1 dose; 1 dose/1 mL x 10 mL = 10 doses

Appendix D: Sample Online Exam #1

Preview Assessment: Online Exam #1

Name	Online Exam #1
Instructions	You are ENCOURAGED to work in groups. You will not know your score until all students have submitted their exams. At that point, you can come back into the exam to see your score and the correct answers. Good luck!
Multiple Attempts	Not allowed. This Test can only be taken once.
Force Completion	This Test can be saved and resumed later.

Question 1 — 5 points

A physician prescribes 60 mL of phenoxymethyl penicillin for oral suspension containing 6,006,000 units. How many penicillin units will be represented in each tablespoon dose of the prepared suspension (no commas)?

Question 2 — 5 points

A solution for direct IV bolus injection contains 125 mg of diltiazem HCl in each 25 mL of injection. What is the conc. of drug in mcg/mcL?

Question 3 — 5 points

If a low-strength aspirin tablet contains 81 mg of aspirin per tablet, how many tablets may be prepared from 1 kg of aspirin?

Question 4 — 5 points

A pycnometer weighs 21.62 g. Filled with water, it weighs 46.71 g; filled with another liquid, it weighs 43.28 g. Calculate the specific gravity of the liquid.

Question 5 — 5 points

A half liter of D5W contains 2000 mcg of added drug. How many mL of

fluid would contain 0.5 mg?

Question 6 5 points

How many grams of dextrose are required to prepare 4000 mL of a 5% w/v solution?

Question 7 5 points

Convert the following into mcg/mL
Prostrate specific antigen 3 ng/mL

Question 8 5 points

The specific gravity of a liquid is 0.815. What is its specific volume?

Question 9 5 points

If a chemical costs $35/lb, what is the cost of 2 oz in dollars?

Question 10 5 points

In preparing a certain ointment, a pharmacist used 28.35 grams of zinc oxide instead of the 31.1 grams called for. What is the percent error based on the desired quantity?

Appendix E: Sample Online Exam #2

Preview Assessment: Online Exam #2

Name	Online Exam #2
Instructions	This exam will be available from Thursday, November 19th at 4 pm until Tuesday, November 24th at 3 pm. It must be submitted on or before 3 pm on the 24th for credit. You will be able to look at the exam and print it out during that time. You may only submit it once. Correct answers and grades will not be available until after the exam has closed. PLEASE include only numbers and not units in your answer.
Multiple Attempts	Not allowed. This Test can only be taken once.
Force Completion	This Test can be saved and resumed later.

Question 1 — 5 points

How many grams of tannic acid must be added to 90 mL of glycerin having a specific gravity of 1.25 to make a 30% (w/w) solution?

Question 2 — 5 points

In preparing an intravenous infusion containing sodium bicarbonate (NaHCO3 - mw = 84), 30 mL of a 3.5% sodium bicarbonate injection was added to 600 mL of 5% dextrose injection. How many milliequivalents of sodium would be in 100 mL of the final infusion?

Question 3 — 5 points

How many grams of zinc oxide should be added to 1250 grams of a 10% zinc oxide ointment to prepare a product containing 25% zinc oxide?

Question 4 5 points

Rx

Lactic Acid	15% (w/v)
Salicylic Acid	10% (w/v)
Flexible Collodion qs	35 mL

Sig. For wart removal. Use externally as directed.

How many milliliters of an 65% (w/w) solution of lactic acid with a specific gravity of 1.21 should be used in preparing the prescription?

Question 5 5 points

An opthalmic solution of naphazoline hydrochloride is stabilized with 0.0006% (w/v) of sodium carbonate. Express this concentration as a ratio strength.
Your answer = 1: _____

Question 6 5 points

If 1150 grams of dextrose are dissolved in 1500 mL of water with a resultant total final volume of the solution of 2 liters, what is the percentage strength in the solution on a w/w basis? Assume a specific gravity of 1 for water.

Question 7 5 points

A solution contains 490 mg of sodium fluoride per 30 mL and has a dose of 15 drops. If the dispensing dropper calibrates to 20 drops/mL, how many milligrams of sodium fluoride are contained in each dose?

5 points

Question 8

A 120-mL vial containing 1 mg/mL of the drug alteplase is added to 220 mL of D5W and administered intravenously with an infusion set that delivers 18 drops/mL. How many drops per minute should be given to administer 30 mg of the drug per hour?

Question 9 5 points

If a pharmacist adds 6 grams of hydrocortisone to 60 grams of a 5% (w/w) hydrocortisone cream, what is the final percentage strength of hydrocortisone in the product?

Question 10 5 points

How many grams of salicylic acid should be added to 300 grams of a polyethylene glycol ointment to prepare an ointment containing 2% (w/w) salicylic acid?

Appendix F: Example Concentration Tutorial from Pharmaceutical Calculations

Pharmaceutical Calculations
Concentration Tutorial

Expressions of Concentration

Percentage

Percentage (%) means rate per hundred. 50 % means 50 out of 100 or 50 parts of each 100. Fifty per cent is equivalent to 50 / 100 or .50.

Percentage can refer to three types:

- Percent weight-in-volume (w/v) expresses the number of grams of a constituent in 100 mL of a liquid preparation. It does not imply that water is the solvent.

- Percent volume-in-volume (v/v) expresses the number of milliliters of a constituent in 100 mL of a preparation.

- Percent weight-in-weight (w/w) expresses the number of grams of a constituent in 100 grams of preparation.

When used without clarification, % is implied to have the following meaning:

For solutions or suspensions of solids in liquids, (w/v) is implied.

For solutions of liquids in liquids, (v/v) is implied.

For mixtures of solids or semisolids, (w/w) is implied.

For solutions of gases in liquids, (w/v) is implied.

In most cases, the use of percentage concentrations in pharmaceuticals is restricted to those cases where the dosage of active therapeutic agent (ATI) is not specific. Ointments, lotions, and estrnal solutions are frequently expressed in percent strength. Tablets, capsules, and oral solutions are normally expressed in more definitive units of measure.

Helpful Equations:

- (w/v)
  - Volume(mL) x % (expressed as a decimal) = grams of solute or constituent
- (v/v)
  - Volume(mL) x % (expressed as a decimal) = milliliters of active ingredient
- (w/w)
  - Weight of solution(g) x % (expressed as a decimal) = g of solute

Practice Problems:

Test Yourself

Self Check

Quiz Me

Test Yourself

Self Check

Ratio Strength

Another way of expressing concentrations is as a ratio. For example 5 parts per 100 designates a mixture with 5 parts of active ingredient in 100 parts total. Ratio strengths are customarily written in ratio form. e.g. 5:100 When a ratio strength is given, it is assumed to have the following meaning, depending on the form of the active ingredient.

For example a ratio strength of 2:500 is assumed to mean:

2g of solute in 500 mL of preparation for solids dissolved in liquids.

2 mL of constituent in 500 mL of preparation for liquids dissolved in liquids.

2 g of constituent in 500 g of mixture for solids mixed into solids.

Percentage strength can be converted to ratio strength by changing the % to :100.

For example, 1 % = 1:100 as a ratio strength. For some ratios, it will be useful to re-express the ratio as an equivalent ratio using whole numbers. For example, .5% = .5:100 = 1:200.

A related topic is the expression parts per million or parts per billion. These can be considered as ratio strengths. For example 5 ppm is equivalent to a ratio strength of 5:1000000 or 1:200,000.

Examples:

1. How many milligrams of hexachlorophene should be used to compound 10.0 grams of a 1:400 ratio strength?

1 gram hexa chlorophene / 400 grams total = X grams hexachlorophene / 10 grams total

X = .025 grams = 25 mg

1. A topical solution contains 85 mg of active ingredient per 100 mL at 15 C. Express this concentration as a ratio strength.

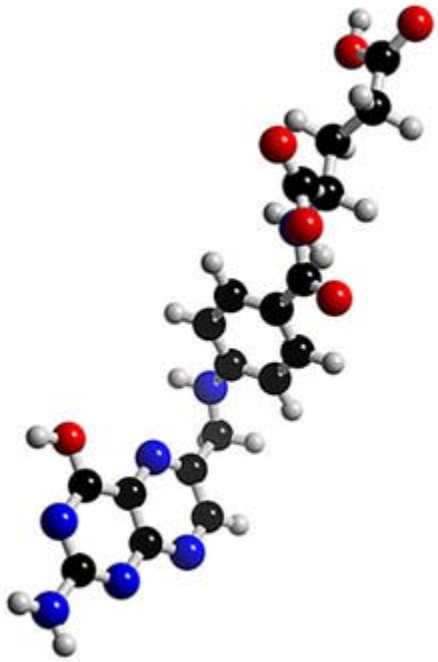
100 mL = 100 g = 100,000 mg

85mg active ingredient/ 100,000 mg total = 1part active ingredient/ X parts total

X = 1176

Ratio strength = 1 : 1176

Test Yourself



Molecular Image of Folic Acid

Vitamin Preparation

Extensions of Percent and Ratio Strength

Your book provides several extensions of percentage and ratio strength to pharmaceutical practice. For example, the authors have provided easy conversions from per cent and ratio strength to mg/mL. They also discuss the concept of mg% as it relates to the concentration of materials in the blood.

Dilution

A final discussion that needs to be made at this point is the concept of dilution. Diluting a solution is the process of adding more solvent(usually water) without adding more active

ingredient. Typically a dilution is specified as _____-fold. A fifty-fold dilution refers to taking one part of the original solution and adding 49 parts of solvent to create a new solution with fifty times the original volume. A simple proportion calculation will allow you to convert from the concentration of the original solution to the concentration of the final solution.

Example:

A 500 mL sample of 1% dextrose in water is diluted 100-fold. What is the new volume and what is the new concentration?

500 mL x 100 = 50000 mL new volume

5g dextrose / 500 g original solution = 1%

5g dextrose / 50000g = 0.01 % after dilution

Test Yourself

A 50 ml of 3% dextrose in water solution is diluted 50 fold.

True or False

Appendix G: Example Alligation Tutorial from Pharmaceutical Calculations

Pharmaceutical Calculations
Alligation Tutorial

Alligation

Alligation Medial

Alligation Medial is a method by which the weighted average percentage strength of a mixture of two or more substances of known amount and concentration may be easily calculated. The percentage strength of each component is first expressed as a decimal fraction. Each percentage strength is multiplied times its corresponding quantity. The sum of these products is then divided by the total quantity of the mixture to get the resultant strength expressed as a decimal. It can then be multiplied times 100 to get the percentage strength of the mixture.

Examples:

What is the percentage strength v/v of alcohol in a mixture of 5000 mL of 40% v/v alcohol, 1000 mL of 60% v/v alcohol, and 5000 mL of 70% v/v alcohol?

% ÷ 100 X	Volume =	Product
0.40	5000 ml	2000
0.60	1000 ml	600
0.70	5000 ml	3500
Total	11000 ml	6100

2000 + 600 + 3500 = 6100 / 11000 mL total = .555 = 55.5% This makes sense since we know the answer must be between 40 and 70 %.

What is the percentage of zinc oxide in a mixture of 100 g of 10% ointment, 50 g of 20 % ointment, and 200 g of 5 % ointment?

% ÷ 100 X	Grams =	Product
0.10	100	10
0.20	50	10
0.05	200	10
Total	350	30

10 + 10 + 10 = 30 / 350 g total =0.0857 or 8.57%

Self-Check

Self Check

Test Yourself

Alligation Alternate

Alligation Alternate is the means by which we calculate the amounts of two known solutions needed to prepare a solution of desired strength. The strength of the desired mixture must be between the strengths of the two available mixtures. Note: Alligation alternate will also allow the blending of inert ingredients(0%) or pure components (100%).

Example:

In what proportions should 95% and 50% alcohol be mixed to obtain 70% alcohol?

95 - 70 = 25 parts of the **weaker** solution

70 - 50 = 20 parts of the **stronger** solution

Note the reversal, you take the difference between the **strong** and the desired and that becomes the parts of the **weak** solution. The difference between the **weak** and desired becomes the parts of the **strong** solution.

In what proportion should a 10% ointment be mixed with inert base to produce a 2 % cream?

10 - 2 = 8 parts inert base

2 - 0 = 2 parts of 10 % ointment

10 parts total

How many milliliters of a 2% and a 7% w/v solution should be used to prepare 500 mL of a 3.5 % solution?

Finding proportions first,

7 - 3.5 = 3.5 parts of 2% (weaker solution)

3.5 - 2 = 1.5 parts of 7 % (stronger solution)

5 parts total

500 mL (total solution we want) x 3.5 / 5.0 = 350 mL of 2%

500 mL x 1.5 / 5.0 = 150 mL of 7%

Self-Check

Quiz Me

Self Check

Three Component Alligation

Three component alligations are made more complicated because there are a multiplicity of combinations that will give the correct composition.

One correct result is to blend the lowest concentration separately with the two highest concentrations to make the correct mixture and then add the results of the two 2-component blends.

Example:

In what ways can 50%, 20%, and 5% zinc oxide prepare 10% zinc oxide?

First, mixing 50 % and 5%, I would need:

50-10 = 40 parts of 5 %

10-5 = 5 parts of 50 %

Second, mixing 20% and 5%, I would need:

20 – 10 = 10 parts of 5%

10 – 5 = 5 parts of 20%

Putting the two chunks together, I would need:

40 parts of 5% + 10 parts of 5% = 50 parts of 5%

5 parts of 50%

5 parts of 20 %

This is only one possibility among many!!!

Another frequent type of 3 component problem will ask the volume of a third component that is needed to be blended with two other solutions to reach a desired composition. This can be done by first blending the two given solutions as a 2-component blend, then doing a second 2-component blend between that result and the third solution of the original problem.

Example:

How many grams of water would be needed to add to a mixture of 50 grams of 5% dextrose and 100 grams of 10 % dextrose to adjust the composition to 6%?

Procedure:

First, use alligation medial to blend the given amounts of the 5% and 10% materials.

%	Amount	Product
0.05	50	2.5
0.10	100	10
Total	150	12.5

10 + 2.5 = 12.5 / 150 = .0833 = 8.33 % and it's 150 g total

Second, use alligation medial again to blend the 150 grams of 8.33 % with water to get the desired 6%.

%	Amount	Product
0.0833	150	12.495
0	X (Unknown)	0
	150 + X	

12.495 / 150 + X = .06

12.495 = 9 + .06 X **X = 58.25 grams to be added**

You try it!

How many grams of inert material need to be added to a mix of 250 g of 6% and 750 g of 10% to produce an 8% ointment?

Answer:

Specific gravities can also be blended using alligation medial under the assumptions that there is not a volume change on mixing and that all volume units are equal.

Example:

What is the specific gravity of a mixture of 1000 mL of syrup with a specific gravity of 1.30 with 1000 mL of an elixir with specific gravity of 0.950?

Sp. Gr.	Volume	Product
1.30	1000	1300
0.950	1000	950
Total	2000	2250

1300 + 950 = 2250 /2000 mL = Answer

Self-Check

Self Check

Appendix H: Survey Questions

Survey Questions

1	I like the idea of online lectures.
2	I believe online lectures will help me to complete my homework questions.
3	The audio/video quality of the online lectures is adequate for my needs.
4	The online lectures will help me understand complex concepts.
5	I will use the online lectures to review for exams.
6	I prefer face-to-face lectures.
7	I hate math problems.
8	I like the online lectures because I can skip material I already understand.
9	The tutorials will be helpful to me to review material from the book/lectures.
10	I prefer to see my professor when he is talking.
11	I will spend more time studying the online lectures than I would with regular class notes.
12	I will learn more with online lectures than face-to-face lectures.
13	I would rather borrow notes from someone than use the online lectures.
14	I like to study in a group rather than alone.
15	I learn better from my professor than my peers.
16	I learn best alone.