THE IMPACT OF AN ONLINE COMPONENT IN A FACE-TO-FACE COMMUNITY COLLEGE MATHEMATICS CLASS

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By
Caroline Dawson
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CERTIFICATION OF APPROVAL

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DEDICATION

This is dedicated to Alex, Donald, Emily, Rich, and Tess. Thank you for the encouragement and support.

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ABSTRACT

A recent trend in the traditional mathematics classroom is the use of online homework systems. Where traditional homework problems are retrieved from a textbook, online homework systems provide problems online and permit students to interact with the system in order to complete homework assignments. Mathematics instructors who use or who wish to use such a system can benefit from knowing the effects of the online homework system. This study sought to determine the impact of an online homework system in a face-to-face college mathematics course. Differences in academic achievement were compared for online homework and textbook homework students. The results indicated no significant differences in academic achievement. Student perceptions of the system were gathered. Students perceived the system to be beneficial and enjoyed using it. Instructor perceptions were also gathered. Instructors perceived the system to be beneficial to students and reported that student achievement had improved in their own courses as a result of using the online homework system.

CHAPTER I

INTRODUCTION

The community college has been a national fixture for over a century. Between its open-access enrollment and its variety of educational options, the community college provides many opportunities for people who may not have been able to attend a university (Wattenbarger, 1995). According to the California Community College Chancellor's Office (CCCCO), the multiple missions of the community college include transferring students to the university, graduating students with associate degrees, awarding students with certificates, providing remediation, and offering life-long learning courses.

While community college students may have a variety of goals, two of the most notable are transfer to a four-year institution and attainment of the associate degree. In both cases, students are required to complete a designated type and number of courses in order to satisfy the requirements for transfer or degree. Students successfully complete a minimum mathematics requirement as part of the required general education coursework for the associate degree. In many cases, satisfying a particular mathematics requirement is necessary in order to prepare students for higher level mathematics courses or for courses outside of the discipline requiring mathematical knowledge and abilities.

In the fall semester of 2009, all community colleges in California began to require at least Intermediate Algebra for attainment of any associate degree. The one exception was for continuing students, who retained the catalog rights associated with

a mathematics requirement of Beginning Algebra (ASCCC, 2008). As a result, more students must now achieve at higher mathematical levels than previously required. This poses a substantial challenge to students and the community colleges since the success rate for mathematics is quite low. Information provided by the CCCCO Data Mart indicates that the state-wide total enrollment success rate for mathematics courses in the spring semester of 2011 was a low 53.75%, while the statewide success rate at the Intermediate Algebra level was even lower at 50.16%.

When considering the current level of mathematics success along with the mathematics requirements for graduation or transfer, it seems logical that efforts to improve student success in mathematics would be an important focus for community colleges. The topic of student success has been a major focus of the entire California Community College system for a number of years. Two notable attempts to improve student success in transfer and graduation have been the Basic Skills Initiative (BSI, 2006) and the Student Success Task Force (SSTF, 2012) recommendations. Both have sought to improve student success through changes in instructional and operational approaches (ASCCC, 2012).

Through the BSI and the SSTF recommendations, colleges have been encouraged to develop innovative and research-supported methods in order to help more students to succeed in mathematics. A number of the successful approaches have focused on improvement in existing programs or creation of new programs. Colleges have beefed up tutorial programs, offered Learning Communities and Supplemental Instruction, and grouped incoming freshmen into cohorts in order to

enhance the first year experience (BSI, 2006). Colleges may be finding increased success through these approaches; however, each program requires money for sustainability. Given the grim current and future budget outlook in California, it seems reasonable to seek out additional improvements that require little to no increase in costs.

A recent trend in the mathematics classroom has been to include an online homework system in a traditional face-to-face classroom setting (Mendincino, Razzaq, & Heffernan, 2009; Peng, 2009; Zerr, 2007). There are a variety of reasons that an instructor might include such a component. Publishing companies hail the online homework system to be helpful to both student and instructor. Depending upon the online homework system, students may be able to access all homework problems online, receive immediate feedback as to the correctness of the answer, seek hints for completing problems, view online tutorials for each specific problem, and even contact their instructor for additional help on specific problems.

If students are submitting homework and receiving feedback from the online homework system, there is an opportunity for instructors to devote less time to processing and grading homework. Because students submit assignments to the homework system, instructors are not required to collect, grade, record, and return paper homework. Less class time is devoted to the collection and dissemination of homework. In addition, instructors are able to monitor an entire class's performance on particular problems and can determine which topics may need additional emphasis during class time. This is very difficult to accomplish with textbook homework. By

the time instructors have processed assigned homework in order to determine which topics are challenging for students, too many days have likely elapsed in order to properly intervene with students.

The online homework system does offer hope to instructors. It appears to benefit both students and instructors, especially with respect to immediate feedback and time. Studies have supported that online homework either helps students to achieve at higher academic levels or it is at least equal to textbook homework (Mendicino et al., 2009; Richards-Babb, Drelick, Henry, & Robertson-Honecker, 2011; Zerr, 2007). There are studies which support that online homework, when compared to textbook homework, provides the biggest boost in academic achievement for students who are struggling. This is especially true for those who might not have otherwise passed (Brewer & Becker, 2010; Lenz, 2010). If struggling students do benefit from online homework, it makes sense to utilize such a component in order to help more students achieve success in mathematics coursework.

Many factors can contribute to the successful use of an online homework system. Students must have the technological ability and access in order to successfully use the system. Instructors must be familiar with the online homework system and be able to provide the necessary support for students to be successful with the system. One example of such a homework system is MathXL. According to the Math XL Website (n.d.), MathXL is an online homework, tutorial, and assessment system offered by Pearson Education as an accompaniment to its textbooks. With

MathXL, instructors develop student homework assignments through algorithmically generated exercises. In addition, a set of detailed homework records is kept by the system so that instructors can determine how many points students have earned and what topics or problems students found challenging. MathXL provides students with computer generated homework problems and can generate immediate feedback as to the correctness of completed problems. Students are able to access the system for hints in problem solving, tutorials, and an online textbook. Options even exist for specialized study plans based on student test results.

Many students enrolled in the community college are being required to or have the option to utilize an online homework system. Studies indicate that online homework systems provide students with at least equal mathematics success when compared to textbook homework and that online homework may most benefit lower-achieving students (Brewer & Becker, 2010; Mendicino et al., 2009). It may be worth the effort to educate faculty members and administrators on the benefits of offering such a system to students.

Statement of the Problem

Success in Intermediate Algebra at the community college is important because successful completion of the course fulfills the associate degree mathematics requirement for many majors and permits students to enroll in college-level mathematics courses for the purpose of transfer. At the college included in this study, 86% of students who participated in the 2010/2011 academic year mathematics assessment were placed into pre-collegiate mathematics courses, which would be

described as Intermediate Algebra or below. The success rate for pre-collegiate mathematics courses in the spring of 2011 was low at 50.8%. If only Intermediate Algebra is considered, the success rate during the same semester was even lower at 49.27% (CCCCO, n.d.; Merced College, 2012). When the Intermediate Algebra success rate of 49.27% from this college is compared with the statewide Intermediate Algebra success rate of 50.16%, it becomes apparent that the problem of low success rate in Intermediate Algebra is an issue across all of the California community colleges.

While an Intermediate Algebra success rate of 49.27% appears to be low, it actually represents an improvement at the institution. In the spring of 2000, the pre-collegiate mathematics success rate was about 43%. This success rate slowly rose over the years by about 10% (CCCCO, n.d.). It is difficult to determine what factor or combination of factors led to this increase in success. There have been a variety of measures taken in order to improve the success rate in pre-collegiate mathematics courses.

In the fall of 2000, all new mathematics instructors were required to teach part of their load in pre-collegiate courses, which was a change from prior years in which part-time faculty members taught most of the pre-collegiate courses. This provided more consistency in instructors and increased instructor access for students. Beginning with the fall semester of 2004, a Supplemental Instruction (SI) program was instituted for pre-collegiate mathematics courses. Depending on the semester, there have been between 2 and 13 sections with SI for Pre Algebra, Beginning

Algebra, and Intermediate Algebra courses. In the fall semester of 2009, the curriculum was overhauled for Pre-Algebra, Beginning Algebra, and Intermediate Algebra. Pre-Algebra was increased from 3 units to 4 units and Beginning and Intermediate Algebra were reduced from 5 units to 4 units. The material covered in each course was modified to provide a more cohesive progression through the courses. In the fall semester of 2009, online homework was introduced for many sections of Pre Algebra, Beginning Algebra, and Intermediate Algebra. The number of sections offering or requiring online homework has increased since this time. The students are permitted to access the online system from a college computer lab or any off-campus location.

As of the spring semester 2012, there have been no studies performed in order to ascertain the effects of the multiple changes implemented over the years at this institution. One of the most recent changes is the introduction of the online homework system into Pre-Algebra, Beginning Algebra, and Intermediate Algebra. While online homework is an option that is available to all instructors, there does not appear to be consistent use of the online system by all. If online homework can increase student success in mathematics, it is worth determining whether online homework is an option that should be encouraged among mathematics faculty members. The outcomes of this research will help to identify whether online homework is an option that should be encouraged among instructors.

Purpose of the Study

The purpose of the study was to determine the impact of an online homework system, specifically MathXL, in a face-to-face community college Intermediate Algebra course. Academic achievement and student perceptions were studied. In addition, instructor perceptions of impact of the online system were gathered in order to better inform the final analysis of the study.

Research Questions and Related Hypotheses

The following overarching question were explored through the research: What impact does an online homework component have in a face-to-face community college mathematics course?

Research Question 1: What is the difference in academic achievement between Intermediate Algebra students who use online homework and students who use textbook homework?

H1: There is no statistically significant difference in academic achievement between Intermediate Algebra students who use online homework and those who use textbook homework.

$Q1_A$: What is the difference in academic achievement between online homework and textbook homework Intermediate Algebra students when controlling for beginning academic achievement level?

$H1_A$: There is no statistically significant difference in academic achievement between Intermediate Algebra students who use online

homework and those who use textbook homework when controlling for beginning academic achievement.

$Q1_B$: What is the difference in academic achievement between online homework and textbook homework Intermediate Algebra students based on the number of course attempts?

$H1_B$: There is no statistically significant difference in academic achievement between Intermediate Algebra students who use online homework and those who use textbook homework based on the number of course attempts.

$Q1_C$: What is the difference in academic achievement between online homework and textbook homework Intermediate Algebra students based on how students were placed in the course (placement test versus passing previous college math course)?

$H1_C$: There is no statistically significant difference in academic achievement between Intermediate Algebra students who use online homework and those who use textbook homework based on how students were placed in course (placement test versus passing previous college math course).

Research Question 2: How do Intermediate Algebra students use and perceive the online homework system?

Research Question 3: What are the perceptions of Intermediate Algebra instructors as related to the student perceptions and their own experience?

Significance of the Study

This study is important because it investigated the impact that an online homework system had in a community college Intermediate Algebra course. Success rates are notoriously low in Intermediate Algebra for individual colleges and statewide. Because many students require Intermediate Algebra for entry into college level mathematics or as an associate degree graduation requirement, it is important to seek out ways to improve student success in the course. This study may provide insights into the effects of online systems on both student achievement and student perceptions.

Mathematics instructors and administrators may be interested in the results of this study. The findings of this study might be useful to mathematics instructors who do use and those who do not use an online system in their mathematics courses. Mathematics instructors who do use an online homework system may be concerned about the impact of the online system on their students. This research might answer some questions for those instructors. Mathematics instructors who do not use an online homework system might either be compelled to try an online homework system or to continue with textbook homework. Administrators who are concerned with improving student mathematics achievement might find the results useful. Depending on the outcomes of this study, administrators might encourage or discourage use of an online homework system by mathematics instructors.

Theoretical Framework

Constructivist theory is a learning theory that describes the manner in which the mind mentally processes content in order to produce learning. Piaget (1970) explained that learning occurs when new information or ideas are connected to existing knowledge, and that knowledge is created through contact with one's environment. The learner acquires additional knowledge by connecting new information to existing knowledge, often through a process called scaffolding. In scaffolding, the learner builds new knowledge with assistance from the immediate environment. This is often accomplished through work with teachers, tutors, and other students, but may also be accomplished through interaction in an online system. According to Valkenburg (2010), scaffolding in the learning environment resembles scaffolding used in construction. Supports are provided until the final product has been accomplished. When students are attempting to gain new knowledge, scaffolding provides the support necessary for students to attach the new information to their existing knowledge.

Constructivist theory relates to this study because students have the opportunity to develop knowledge through the variety of help options presented by the MathXL program. Since constructivist theory posits that learning occurs by a person making sense of new information based on prior knowledge and their surroundings, it is reasonable to expect that multiple student help options would serve to provide such a learning experience. While the concept of scaffolding in constructivist theory often involves the learner and at least one other person, it is

reasonable to suggest that an online homework system, such as MathXL, could provide enough guidance to result in knowledge acquisition by the student.

Hatziapostolou and Paraskakis (2010) discussed the importance of formative feedback with respect to student learning. While summative feedback provides students with information when they have completed an assignment or exam, formative feedback provides guidance in the midst of an assignment. As a result, students are better able to ascertain whether they have learned what they should have learned prior to receiving the summative feedback. In order for formative feedback to be effective, it must be timely, personal, manageable, motivational, and directly related to assessment criteria (Hatziapostolou & Paraskakis, 2010).

Formative feedback connects to this study because the focus is on an online mathematics homework system, MathXL, which provides immediate formative feedback to students. This type of feedback is provided for every problem throughout the assignment. As students work from one problem to the next, they are provided guidance. In textbook homework, if homework feedback is provided at all, it is provided in a summative format, where students receive the feedback from the instructor after they have already submitted the assignment. In summative feedback, students receive assistance on problems long after they have moved on to the next topic. As a result, students may misunderstand important concepts and move forward with a weak mathematical foundation. Formative feedback permits students to move forward in their learning with a minimization of possible misunderstandings and gaps in knowledge.

As students progress through homework problems, they may occasionally need assistance in completing problems. MathXL provides students with numerous opportunities to make sense of the new material. *Help Me Solve This* is an option which guides students through the problem in question by providing some of the solution and presenting opportunities for students to fill in missing pieces of the solution as they progress through the option. The *View an Example* option allows students to see the problem being solved step by step, where no student input is required. *Textbook* is an option which takes students to the appropriate location in the online textbook so that students can review the topic. *Ask My Instructor* permits students to email their in-progress problem to their instructor so that they might receive guidance for completion of the problem. The variety of options presented for student knowledge-building is student-centered in nature. Students are provided many opportunities to learn new concepts, and it is through their own preferences that they can accomplish this with MathXL.

Formative feedback would appear to enhance the construction of knowledge for students. Students attend lectures and complete homework. The formative feedback provided by MathXL can give students a reality check. If students know that they are successfully completing the homework problems while they are in the midst of the assignment, they are likely to feel confident in their understanding of the material. If, on the other hand, students are given feedback that they are incorrectly doing the problems, they can seek out help from the system or the instructor to rectify the misunderstanding. This could provide better opportunities for learning when

compared to textbook homework, since students receive immediate feedback instead of waiting for the homework to be graded. With textbook homework, the feedback might be received too late in order to help the students effectively learn new material.

Definitions

Academic Achievement. Academic achievement is measured by the score earned on the Intermediate Algebra final exam.

Beginning Academic Achievement Level. Beginning academic achievement level is measured by the score earned on the first Intermediate Algebra exam, which represents a review of Beginning Algebra material.

Course Placement by Placement Test. Course placement by placement test refers to a student's immediate placement in Intermediate Algebra as a result of a placement test score.

Course Placement by Previous Math Course. Course placement by previous math course refers to student's placement in Intermediate Algebra as a result of successfully passing the prerequisite course of Beginning Algebra.

MathXL. MathXL is an online homework, tutorial, and assessment system offered by Pearson Education as an accompaniment to its textbooks.

Number of Course Attempts. The number of course attempts represents the number of times a student enrolled in Intermediate Algebra at the college where the study was performed.

Online Homework. Online homework describes the homework assignments developed through MathXL, which accompanies the textbook *Beginning &*

Intermediate Algebra, Fourth Edition, by Elayne Martin-Gay (2009). All assignments were developed by the instructor. Students retrieved and submitted assignments using the online system.

Textbook Homework. Textbook homework describes the homework assignments selected from the textbook *Beginning & Intermediate Algebra*, Fourth Edition, by Elayne Martin-Gay (2009).

Learning Communities. Learning communities are pairs or clusters of courses that revolve around a theme or major.

Supplemental Instruction. Supplemental Instruction is an academic assistance program that utilizes peer-assisted study sessions to help students with traditionally difficult academic courses.

Summary

The purpose of this dissertation was to determine the impact of online homework in a face-to-face community college mathematics course. There are a total of five chapters in the document.

Chapter II contains a literature review in which research related to the following will be discussed: the influence of homework on learning and achievement, how community college students learn, technology's influence upon learning, and computer-based homework research.

Chapter III presents the methodology to be used in the study. The research design was a mixed-methods design. Pre-test and post-test measures were used to test for differences between the online homework group and the textbook homework

group. In addition, surveys were administered and a focus group was conducted in order to determine student perceptions of the online homework system.

Chapter IV gives descriptive statistics from the surveys, themes from the surveys and the discussion group, and statistical results from the analyses.

Chapter V provides a summary of the study. Conclusions related to the findings are discussed. In addition, implications from the study and future areas of research related to the study are presented.

CHAPTER II

REVIEW OF THE LITERATURE

The review of literature focuses on the following: the influence of homework on learning and achievement, community college students, community college student success in mathematics, technology in teaching and learning, and the impact of feedback on learning.

Influence of Homework on Learning

Numerous studies which focus on student completion of homework have been conducted. The contribution of homework to academic achievement appears to be a prevalent focus of research related to the topic (Cuadros, Yaron, & Leinhardt, 2007; Keith, Diamond-Hallam, & Fine, 2004; Patall, Cooper, & Wynn, 2010; Ryan & Hemmes, 2005).

In order to determine the impact of homework at the course level, Cuadros et al. (2007) investigated how student completion of homework contributed to learning. The sample consisted of 137 college students in a second semester introductory chemistry course. Students were given three exams, three pre-tests prior to those exams, and a final exam. Homework scores were determined from all homework which was to be completed prior to each of the three regular exams. A multiple linear regression analysis was conducted to predict variation in final course achievement (final exam plus third exam) from a combination of student independent learning (exam scores) and student guided learning (homework scores). The results of the analysis indicated that student independent learning and student guided learning

accounted for 48% of final course achievement variability, with no provided *F*-value and $p < .001$. Student independent learning and student guided learning equally contributed to the variation in final course achievement.

Another study compared homework completion location and student's overall grade point average (GPA). Keith et al. (2004) sought to determine the effects of homework completed during school and homework completed outside of school on the grades of high school students. The sample consisted of data retrieved from the National Education Longitudinal Study (NELS), which represented 13,546 students. Students included in the sample completed surveys in their 8^{th}, 10^{th}, and 12^{th} grade years. Achievement was measured by senior grade point average, which included grades in English, mathematics, science, and social studies. Students reported the amounts of time spent on in-school and out-of-school homework. Structural Equation Modeling (SEM) was used to determine the effect of in-school and out-of-school homework on senior GPA. Assuming that the developed model was correct, the path from in-school homework to GPA was small at .01 and non-significant; however, the path from out-of-school homework to GPA was large at .28 and statistically significant. Results indicated that homework completed outside of school had a strong effect on the student grade point average in 12^{th} grade, while homework completed inside of school had no significant direct effect.

While research supports that homework completion affects academic achievement, this finding does not necessarily entice students to complete homework based on increased academic achievement alone. Ryan and Hemmes (2005)

attempted to determine if homework completion and quiz grades would differ as a result of offering designated homework assignments for credit and others for no credit. Students were encouraged to complete non-credit assignments as a way to potentially increase quiz grades. They were also ensured that written feedback would be provided to non-credit assignments just as they were in credit assignments. An experiment was conducted with two different groups of university psychology students in two separate semesters. The first sample consisted of 19 students and the second consisted of 17. In each semester, the class was split into two sub-groups, where credit homework and no-credit homework were alternated between groups from one assignment to the next. There were a total of 10 assignments and quizzes throughout the semester. Every student had five opportunities to receive credit for completed homework.

The results indicated that students turned in more and better homework when they were given the opportunity for credit. When students did not have the credit opportunity, they ceased to turn in homework and did not perform as well on quizzes. In the first experiment, the percentage of completed homework in the points condition was $M = 100\%$ and $SD = 0.00$ and the no-points condition was $M = 24\%$ and $SD = 0.21$, where significant differences occurred with $t(18) = 13.8$ and $p < .001$. Quiz scores were significantly higher in the points condition with $t(18) = 1.6$ and $p = .008$. The percentage of scores was $M = 82\%$ and $SD = 0.87$ in the points condition and $M = 72\%$, $SD = 0.86$ in the no-points condition. The results for the second

experiment were similar to the first. While cause was not established, there appears to be a relationship between completing homework for credit and quiz scores.

While research supports that homework contributes to student achievement, there may be potential for greater gains in achievement when students perceive that they have choice in assignments. Patall et al. (2010) studied the effect of homework choice upon academic performance and motivation. The sample consisted of 207 high school students, from 14 different classrooms at two different high schools. The students were given an initial survey, which identified sex, ethnicity, GPA, experience of assignment choice in classes, experience of cognitive autonomy where students fully participate in the pedagogy as well as the course subject matter, perceptions of self-confidence pertaining to school work, and self-regulatory reasons for doing specific types of school work. Students were separated into two groups, where students could have a choice of assignments in one case and have no choice of assignment in the other. There were two units of homework assignments, where the groups switched after the first unit. One unit of homework presented students with options for each assignment, where students could choose from one of two options. The other unit of homework provided students with no choice. A survey called the Intrinsic Motivation Inventory was utilized, which sought to determine whether students were intrinsically or externally motivated to complete homework. Immediately after the first unit and second unit, the Intrinsic Motivation Inventory was distributed.

The findings of the study indicated that providing students with choice in homework assignments enhanced academic performance and student motivation. Unit test scores for students given homework choice were higher with $M = 80.80$ and $SD = 12.45$, while no-choice students had $M = 77.99$ and $SD = 16.93$. When students were given homework choice, their unit test scores were significantly higher than when they were not given choice, where $t(374) = 2.12$ and $p < .05$. Student motivation was also higher for homework choice students with $M = 3.45$ and $SD = 1.23$ and lower for no-choice students with $M = 3.25$ and $SD = 1.13$; however, the means were not significantly different. While choice resulted in positive outcomes, it does create additional work for teachers. This study suggests that finding a balance between student opportunities of choice and feasibility for the instructor may be beneficial to both students and teachers.

Community College Students

The open access nature of the community college permits a very diverse group of students to enroll. A number of studies have been designed to investigate the experience of the community college student.

Kim, Sax, Lee, and Hagedorn (2010) performed a study designed to determine factors which contribute to differences in student self-perception between community college students who identify solely as a student when compared to community college students who identify themselves as “students who are employed,” “employees who attend college,” and “parents who attend college.” The data for this study came from the Transfer and Retention of Urban Community College Students

(TRUCCS) first-year survey, which was administered to 5,000 students enrolled in nine Los Angeles community colleges.

The survey contained 35 self-reported measures based upon a Likert-scale. The following represent the different categories measured: Student Characteristics, Student Activities, Student Educational Challenges, Student Educational Objectives, Institutional Beliefs, and Student Beliefs. The range of Likert values varied. For example, Student Educational Objectives ranged from 1 through 5, where 1 corresponded to "definitely not" and 5 corresponded to "definitely." In contrast, Institutional Beliefs ranged from 1 through 7, where 1 corresponded to "very unimportant" and 7 corresponded to "very important." The survey questions were general in nature; therefore, responses are likely representative of community college students outside of the Los Angeles area.

A discriminant analysis was performed in order to determine self-perception group differences. The predictor variables were the 35 questions from the survey, and the criterion variable was the self-perception classification. The analysis resulted in three discriminant functions, which accounted for 61.1%, 34.9%, and 4.0% of discriminating information from the predictor variables. Reported Wilks's lambda values of .300, .598, and .938 showed statistical significance at the .001 level for each function. The most important variables in the discriminant function were work at a job (.52), doing housework or childcare (.78), age (.82), and family responsibility (.89).

An important conclusion drawn from the study was that students who are classified as traditional because of age may face many of the struggles faced by students categorized as nontraditional based upon age. For example, 42.6% of students under the age of 25 worked more than 20 hours per week, and 36.1% of that same group identified family responsibilities as being a challenge.

Bahr (2010) performed a study designed to determine if successful remediation in community college mathematics differed according to student race. Successful remediation was defined as receiving a passing grade in a college-level mathematics course. Data were gathered from the California Community College Chancellor's Office. The fall of 1995 first-time-freshmen cohort was selected for the study, where N = 167,982. The student records covered a six-year period. Statistically significant racial differences were found with respect to the likelihood of successful remediation, with χ^2 = 1394 and $p < .001$. White students were 3.1 times more likely to remediate successfully than Black students and 1.6 times more likely to remediate successfully than Hispanic students.

A study performed by Pierceall and Keim (2007) sought to measure degrees of stress experienced by community college students. The sample included 212 psychology students enrolled at two community colleges in southern Illinois. The Perceived Stress Scale (PSS) was administered to students. It contained 14 Likert-scale items. The scale ranged from 0 to 4, where 0 represented "never" and 4 represented "very often." The range of points for each student was 1 to 56. A stress level of "low" corresponded to fewer than 20 points, a stress level of "moderate"

corresponded to scores from 20 to 36, and a stress level of “high” corresponded to a score of greater than 36. The mean score for all students was $M = 27.78$ with $SD = 8.22$, which would represent an overall “moderate” level of stress for the entire group.

Scores were compared between traditional and non-traditional students. Traditional students were those whose ages were from 18 years to 23 years. Non-traditional students were 24 years or older. There were 154 traditional age students and 58 were non-traditional. The mean score for traditional students was $M = 28.15$, while the mean score for non-traditional students was $M = 26.81$. The mean scores for the two groups on the PSS were not significantly different, with $t = 1.06$ and $p = .29$. Scores were also compared between men and women. The mean score for women was $M = 29.11$, and the mean score for men was $M = 25.87$. Women were significantly more stressed than men, with $t = -2.87$ and $p = .005$.

Community College Student Success in Mathematics

Nearly 27% of California Community College students were enrolled in pre-collegiate or remedial mathematics coursework in the spring semester of 2011 (CCCCO, n.d.). The success rate for the pre-collegiate group was 51% (CCCCO, n.d.). As a result of the low success in pre-collegiate mathematics, much research has been focused upon success in mathematics at the community college level (Illich, Hagan, & McCallister, 2004; Waycaster, 2011).

Illich et al. (2004) sought to determine if performance in college-level courses is lower for students who are concurrently enrolled in remedial coursework when compared to students who never required remediation. Remedial coursework

included courses in pre-collegiate mathematics and English. A total of 12,375 McLennan Community College students were included in the sample, which included enrolled students from the Fall of 1999, Fall of 2000, and Fall of 2001. Thirty percent of the students in the study were enrolled in at least one remedial course. Chi-square tests were run in order to compare course pass rates. The courses included in the analysis were those college-level courses which did not rely upon a remedial prerequisite course. Significant differences were determined between remedial students who had failed at least one remedial course when compared to remedial students who had not failed any courses and non-remedial students, with $p <$ .001 for all three semesters and no reported chi square value. No differences in course pass rates were determined between remedial students who successfully completed remedial courses when compared to non-remedial students. Pass rates determined for the included courses were significantly higher in the fall of 1999 for remedial students who had successfully completed remedial courses when compared to non-remedial students, with $\chi^2(1) = 12.2$ and $p < .001$.

Another study by Waycaster (2011) confirmed the findings of Illich et al. (2004). Waycaster (2011) compared success rates of community college students in first college level mathematics coursework according to whether students had or had not completed a prerequisite developmental mathematics course prior to enrollment into the first college level course. The sample included 148 students who had taken developmental mathematics and 905 students who had not. The success rates were compared for developmental and non-developmental first college level mathematics

course students. The success rate for developmental students was 77% and the success rate for non-developmental students was 75%. A 2-proportion *z*-test was performed on the null hypothesis "there is no difference in success rates between the developmental and non-developmental students." The *p* value was 0.68. As a result the null hypothesis was not rejected. The results of the study confirmed that students who enroll in their first college level mathematics class within a year after having successfully completed their last developmental mathematics class are equally as successful as those students who place directly into the college level class.

A different research focus related to student mathematics success is the role of student mathematics anxiety and successful completion of mathematics coursework. Woodard (2004) sought to determine if a difference in academic achievement existed based upon level of math anxiety. The sample consisted of 125 developmental math students, where 33 were males and 92 were females. The sample was composed of 45 Basic Math students, 51 Algebra I students, and 29 Algebra II students. The setting was at Southwest Virginia Community College. The Mathematical Anxiety Rating Scale (MARS) was used to measure math anxiety. A Pearson Product Moment Correlation was performed in order to determine if any relationship existed between math anxiety levels and academic achievement as measured by an exit exam. The results were $r = -.20$ with $p = .027$. While the weak negative correlation suggests that an increase in math anxiety scores is correlated to lower levels of academic achievement, the study does not provide support suggesting that math anxiety results in lower achievement.

Technology in Teaching and Learning

Various studies have been undertaken to identify the impact of technology in teaching and learning. The manner in which instructors and students use and perceive technology can have an important impact in an educational setting. In addition, the availability of online learning aids for students has resulted in learning options that may or may not benefit students. Specifically, research on the impact of online homework systems is presented.

Brill and Galloway (2007) investigated college instructors' use of and attitudes towards technology in the classroom. A two-phase research study was conducted, in which phase one included faculty surveys and phase two included follow-up interviews of survey respondents. The population of the sample included 1,400 full-time and part-time university professors and graduate teaching assistants. A stratified random sample of 180 participants was selected for the survey according to the level of technological support present in their classrooms, where the sample was composed of professors from 30 high-level, 60 medium-level, and 90 low-level technology classrooms. Surveys were completed by 53 instructors, and 10 of those instructors agreed to participate in follow-up interviews. Themes were developed through the surveys and further discussed in the interviews. The following themes emerged: current and future technology use, influence of technology on teaching and learning, and barriers to technology use. Regarding technology use, the findings confirmed that instructors had the greatest interest in using the following, where the list represents greatest interest to least interest: the Internet, a CD-ROM, an instructor

computer workstation, a video disc player, a large screen video data display, DVD video, and student computer workstations. With respect to teaching and learning, instructors perceived technology to have a positive impact upon their teaching and student learning. Identified barriers were poor classroom environments and lack of equipment.

Another study of instructors and technology by Gonzalez (2010) specifically looked at using the internet in an educational setting. The study sought to identify the value placed upon eLearning by university professors. The sample consisted of 18 university professors from two different universities who had experience with e-learning in their face-to-face classrooms. Interviews were performed with the professors in order to determine variation in perception and experience. The researchers identified the following four categories with respect to the value of eLearning from interview data: providing students with information, communicating among participants, engaging students in online discussions, and supporting knowledge-building tasks. The participating professors provided both administrative and academic information through course websites and links. Online communication provided a venue for students to discuss course matters with each other and the professor. In addition, professors were able to inform students regarding course happenings. Online discussion boards permitted students to have course-related discussions designed to promote high-level understanding and take the focus away from the professor. With respect to supporting knowledge-building tasks, students

utilized the professor's website to seek out learning tools designed to enhance student learning in the course.

Also related to instructor use of technology was a study by Sahin (2008), which sought to determine how certain factors influence College of Education (COE) faculty members' intentions to use technology. A total of 347 COE faculty members at five universities in Turkey were asked to participate in the survey. There were 157 surveys completed. Structural equation modeling was used to understand the relationships among educational technology self-efficacy, outcome expectations, interest, and intention. A model was developed from the Likert-scale items presented in the surveys. Validity of a reduced model including only significant paths resulted in $AGFI = .98$, $RMR = .01$, $\chi^2 = .628$ and $p < .01$. The findings suggested that self-efficacy in, outcome expectations from, and interest in educational technologies significantly contributed to the faculty members' intentions to use technology in the classroom, where 52% of the variance in intention is explained by the model with $R^2 = .52$ and $p < .01$.

The manner in which students perceive technology is important in an educational setting. A study by Edmunds, Thorpe, and Conole (2012) was performed in order to determine student attitudes regarding the use of information and communication technology (ICT) in course study, work, and social activity. The instrument used was the Technology Acceptance Model (TAM), which measures the ease of use and perceived usefulness of technology. A survey was distributed to 1,209 students at a single university in the United Kingdom, and 421 students

responded. The students were enrolled in the following six courses: Cisco Networking, Software Requirements for Business Systems, Team Engineering, Foundations for Social Work Practice, and Applied Social Work Practice.

A Likert-scale questionnaire containing 59 questions was used to measure usefulness, ease of use, and motivation in using ICT. Significant differences in usefulness and ease of use existed between study, work, and leisure when comparing results from academic courses. With respect to usefulness, an ANOVA found $F(2,538) = 116.74$ and $p < .01$. Regarding ease of use, an ANOVA resulted in $F(2,636) = 17.20$ and $p < .01$. The results indicated that students perceived technology to be the greatest help in work situations but also perceived technology to be helpful in a course setting if the technology was easy to use and helped build understanding of the material. Recommendations were given that while colleges may select new technology to assist student learning, attention must be given to students in order to determine if they feel that the technology is easy to use and provides assistance in learning.

The youngest and most prevalent college-attending generation is represented by those students who were born beginning in 1982, the Millennials (Elam, Stratton, & Gibson, 2007). Numerous studies have been completed which focus on the technology use and expectation of the Millennial generation.

There is an idea that Millenials have a natural propensity for technology in all aspects of their lives. Sãnchez, Salinas, Contreras, and Meyer (2011) conducted a study in order to analyze and discuss the idea that a new generation of learners, the

digital natives, has developed unique skills and abilities as a result of their interactions with technology. The sample consisted of 20 Chilean students in grades 8 through 12, with an equal number of male and female participants. Interviews were held in four different cities with students and teachers from high schools of varying socio-economic status levels. The data collected through the interviews were coded, and themes were developed. The emergent themes were as follows: perceptions of practices using communications media and other digital technologies, perceptions of use and meaning of ICT, and perceptions of study practices as related to ICT.

Regarding media and digital technologies, students used a mix of traditional media, such as television and radio, with new media, such as internet and cell phones. While the students used a combination of the technologies daily, the extent of any particular type was unique for each student. With respect to perceptions of use and meaning of ICT, students reported that while computers and the internet are extremely important, direct contact with their friends is irreplaceable by technology. Regarding ICT use at school and for study, students reported that they used the internet to research information for class assignments. Students reported cutting and pasting information straight from the internet. Teachers identified this behavior to be detrimental to student learning. While the study showed a generation of students who shared similar traits, it did not confirm that the entire generation used technology in the same manner. While some had developed the skill to multi-task several technological innovations at once and preferred the fast pace of technology, there was

no evidence that all students had developed learning preferences that differ much from previous generations.

There is an expectation that Millennial students would be comfortable with technology in an educational setting. Greenhow, Walker, and Kim (2010) conducted a study in order to assess high school student access to the internet. The participants included 852 high school students in the upper Midwest. The students came from families who were at or below the median income of the county. A paper survey was administered, which intended to identify the students' experience with the internet. One result was that a large majority of students had considerable experience with the internet. Because of the students' familiarity, the authors indicated instructors should not be apprehensive about using such technology to further the understanding of students. Instructors should be cautioned that students from low-income households do not have the same access as students from wealthier households. The lower-income students typically had to share a computer with numerous family members, which made extended work time on the home computer difficult. The implication is that schools should try to make internet access available for students if they intend to incorporate technology into a course.

Millennial students, as a group, may perceive themselves differently than and have technological comfort levels far beyond previous generations of college students. This may affect student expectations in the classroom. Littlejohn, Margaryan, and Vojt (2010) collected data related to students' prior experience and expectations in learning from 2,215 entering university students from 2001 through

2004. The majority of students were between ages 17 through 20. Students provided answers to a paper survey, which was distributed to them during an induction session on their first day at the university. Themes were developed from student responses. Students described both technology-enhanced learning and learning without technology to be preferred learning approaches. Findings indicated that, despite the increase in use of online technology for personal reasons, students did not seek out technology-related experiences in the classroom. One result indicated that the higher the student's perceived technological ability, the more likely he or she was to seek out technology-infused coursework. While students may be technologically capable, they may not seek out technology in an educational setting if they perceive themselves to have low technological ability. Exposure to and comfort with technology outside of school does not necessarily lead to students seeking access to technology in the educational environment.

Even though students may be comfortable working online, they may have preferences in the types of online experiences that are provided. Percival and Muirhead (2009) performed a study to determine which online resources students would utilize during a semester course, one face-to-face course and the other blended learning. A 60-question Likert-scale online survey was completed by 68 face-to-face students and 38 blended learning students at the end of the semester. The results from the survey indicated that students used available online resources in a similar fashion in both courses. Both groups utilized the on-line test preparation features to the

greatest extent. The students liked the practice tests because they closely resembled the actual questions asked on class tests and provided instant feedback.

One finding was that even though Millennial students are the early adopters of new technology, this does not necessarily translate into natural selection of such learning aids in a course setting. Another finding was that students expect all course resources to be readily available on a single site. Students will not necessarily venture out of the site for additional learning opportunities, especially if an additional log-in is required.

While perception, use, and expectations of technology in the educational environment are important topics of research, it is important to know if the technology is actually helping students to learn. Studies related to online homework systems represent an attempt to determine if students are being helped by such innovations.

Fife (2008) performed a study in order to determine if there were significant differences in academic achievement, as measured by a pre-test and post-test, and persistence, as measured by those students who completed both the pre-test and post-test, for college Intermediate Algebra students who used online homework (MyMathLab) as compared to paper-and-pencil homework. The online homework students and the paper-and-pencil groups were taught with the same textbook. Online homework students were assigned problems that corresponded to those assigned to paper-and-pencil students in the textbook. The online homework provided immediate feedback as to the correctness of each problem completed.

The sample consisted of the treatment group, 93 online homework students, and the control group, which was comprised of 71 paper-and-pencil students. An ANCOVA was used to determine differences in mathematics achievement between the online homework group and the paper-and-pencil group. There were no significant differences with $F(1, 162) = .27$ and $p = .606$. Retention was analyzed through a Pearson Chi-Square statistic. There were no significant differences with $\chi^2 = 2.76$ and $p = .096$.

A study by LaManque (2009) was performed in order to determine if a difference in success would occur for DeAnza College Pre-Algebra, Elementary Algebra, and Intermediate Algebra students through a program called the Enable Math Pilot. The two-year pilot included EnableMath computer software for homework practice, administration of the College Student Inventory, and the inclusion of counseling services in the classroom.

The sample consisted of Pre-Algebra, Elementary Algebra, and Intermediate Algebra students. In the Pre-Algebra group, there were 428 EnableMath students and 1,755 control students. In the Elementary Algebra group, there were 723 EnableMath students and 3,045 control students. The Intermediate Algebra group had 853 EnableMath students and 3,573 control students. These students represented all who were still enrolled as of the fourth week of classes. All participating students were taught with the same textbook. The control group completed problems from the textbook, while the EnableMath students completed homework with the online system, where the problems corresponded to those assigned to the control group. The

EnableMath students received immediate feedback as to the correctness of each completed problem.

End-of-term grade comparisons were made between EnableMath students and the control group students at each level. When comparing the EnableMath and control groups for success, the pass rates were consistently higher for EnableMath Students. At the Pre-Algebra level, 72% of the EnableMath students succeeded, while the control group succeeded at a 58% pass rate. In Elementary Algebra, 71% of the EnableMath students succeeded, while 55% of the control group students succeeded. At the Intermediate Algebra level, EnableMath students succeeded at a 75% rate, while 55% of the control group succeeded. The results for each course level showed the EnableMath sections to have significantly higher success rates. It was reported that Chi Square tests were run for each level and were statistically significant, yet no supporting statistical values were provided in the article.

Using a different online homework system, Hauk and Segalla (2005) performed a study which attempted to measure student perceptions about an online homework system named WeBWorK. A sample of 358 College Algebra students from a single college filled out perception surveys and took a College Algebra concept pre-test and post-test. The WeBWorK homework system provided students with immediate feedback as to the correctness for each completed homework problem. The pre-test and post-test contained the same 25 questions, where multiple choice questions were designed to measure College Algebra concepts and skills. Gains in achievement were measured as a difference between the pre-test and post-

test. There were no significant differences in achievement between the groups; statistical values were not provided by the authors. The achievement results suggested that the online system was at least as effective as paper-and-pencil.

The survey contained Likert-scale questions intended to measure student perceptions of the WeBWorK system. The scale offered choices from 1 through 4, where 1 represented very easy and 4 represented very hard. Means were provided for responses to the survey. For questions about the use of and interface with WebWorK, the mean was 3.1. The mean of responses related to ease of internet access was 2.5. Comfort with the computer had a mean response of 1.7. Results from the survey indicated that students appreciated the immediate feedback provided by the online system.

Studies of online homework are also focused on more advanced mathematics courses, such as Calculus. Zerr (2007) conducted a study in order to assess student perceptions and academic achievement resulting from use of an online homework system. The sample consisted of 23 online homework students and 18 paper-and-pencil students enrolled in a first semester college Calculus course. Students in both groups received the same content instruction and performed similar homework problems. The online homework problems corresponded to those provided in the textbook. The online homework problems provided immediate feedback related to correctness of work.

Academic achievement was measured through student quiz and test scores. Student perceptions were measured through a survey. Through quiz and test scores, it

was determined that student achievement was significantly higher for online homework students when compared to paper-and-pencil homework students. The online homework students had higher test and quiz scores, where the means were 80.61% and 85.15%, respectively. The traditional homework students had test and quiz means of 79.38% and 82.54%. While the test and quiz means were higher for the online group, they were not significantly different at the $p < .05$ level. While the differences between the two groups were not significant, the grade distributions between the two groups showed that the online group had less D and F grades on both tests and quizzes. These results suggest that there might be an academic boost provided to lower-achieving students by the online homework system. No analysis was performed in this study to follow up on the grade distribution results.

In order to measure student perceptions of the online homework system, a survey was administered at the end of the semester. A total of 19 of the online homework students completed the survey. Students were asked to respond with a value from 1 through 5 to two Likert-scale statements, where 1 represented strongly agree and 5 represented strongly disagree. Students responded with a mean of 1.16 on the survey item regarding online homework being a worthwhile addition to the course. The mean was 1.05 with respect to students wanting to see online homework offered in other mathematics courses. Students were also asked to provide a comment, which indicated that students had high praise for the online system.

Another online homework research topic is that of the online homework system and self-efficacy. Brewer's (2011) study compared the academic achievement

and self-efficacy of College Algebra students who used online versus paper-and-pencil homework. The sample consisted of 145 students. Students were given a pre-test in order to determine the amount of prerequisite knowledge they had upon beginning College Algebra. As a result of scores, students were divided into a Low Level of Preparation group and a High Level of Preparation Group. Academic achievement was measured by a departmental final exam. The homework problems assigned to each group were similar. The online homework problems provided immediate feedback as to correctness of each completed problem.

A *t*-test was run in order to determine differences between final exam scores for online and paper-and-pencil groups. There were no significant differences between groups, with $t(143) = -1.487$ and $p = 0.139$. Effect size was calculated using Cohen's *d*, where $d = 0.253$. The online homework treatment had a small effect on the final exam scores of the online homework group. A *t*-test was performed in order to determine differences between final exam scores for online versus paper-and-pencil groups among those classified as Low Level of Preparation. The results showed that the online group performed significantly higher on the final exam with $t(73) = -2.174$ and $p = 0.033$. Effect size was calculated and found to be $d = 0.526$, which indicates that online homework had a medium effect on the final exam scores of Low Level of Preparation students.

Student self-efficacy was measured through a 34-question Likert-scale instrument, which was administered at the beginning and end of the semester. The instrument asked students to assess their level of confidence when asked how

confident they would be in completing a provided mathematical task or in successfully completing a described mathematics course. The Likert-scale ranged from 0 to 9, where 0 represented a response of "No Confidence at All" and 9 represented a response of "Complete Confidence." An ANOVA was conducted in order to determine differences in self-efficacy gains between online and paper-and-pencil groups. There was no significant difference in self-efficacy gains, with $F(1,118) = .84$ and $p = .36$.

Feedback and Learning

This area of research attempts to determine the impact of feedback and its timing on student learning. A variety of studies present the different types of feedback and the learning impact experienced by students.

A study by Clariana, Wagner, and Murphy (2000) examined the effects of different types of feedback on learning. The sample consisted of 52 high school social studies students. Students completed a computer-based lesson containing eight reading passages. There were 36 five-alternative multiple choice questions. Of the questions, 18 were verbatim and 18 were inferential. Students were assigned to three possible groups. The first group was the delayed feedback (DF) group. The students received problem correctness feedback at the end of the lesson. The correct answers to each question were presented; however, students were not made aware of which problems they performed correctly. Students were given time to review the correct answers and had to rely upon their memory of whether they had answered correctly.

The second group of students received single try immediate feedback (STF). On each problem, students provided an answer and were given immediate feedback as to the correctness of the answer. The correct answer was provided at that time. The third group of students received multiple try immediate feedback (MTF). Students provided answers and received immediate feedback after each problem attempt. Students were permitted to continue answering until the correct answer was submitted.

One day later, a retention test was administered to all participating students. The test contained the same 36 questions from the lesson. Questions were classified as easy, midrange, and difficult according to the frequency of correct responses provided by students during the lesson. The results of an ANOVA showed that retention of lesson material was greater for the DF group than the STF group, with $F(2,49) = 4.13$, $MSE = 0.024$, and $p < .05$. The MTF group was reported to be more like the STF group.

Dihoff, Brosvic, and Epstein (2004) performed a study which explored the effects of feedback on learning. The sample consisted of 120 students enrolled in an undergraduate course. Six exams and a final were used to measure learning. Seventy-two hours prior to each exam, students were given a practice test, which closely resembled the impending exam. The practice tests, exams, and final exam each contained multiple guess questions. Students had been equally assigned to one of three feedback condition groups: no feedback, feedback on three practice tests, or feedback on six practice tests. In the no feedback condition, the students recorded

their answers on a Scantron and received a score at the end of the practice test. They were not given feedback as to which answers were correct or incorrect. In the feedback condition, students recorded their answers on special forms called IF AT forms. The forms offered multiple guess options and required students to provide answers by scratching off a coating in order to reveal if they had answered correctly. If students answered incorrectly, they would continue to answer until they had uncovered the correct answer. A practice test was not provided for the final exam.

In order to determine differences in test scores, separate ANOVAs were conducted based upon number of practice tests in which feedback was provided. Test scores were significantly higher for students in the feedback condition, all $F > 11.27$ and all $p < .0001$. There was no significant difference in final exam scores based upon feedback condition.

Feedback and learning literature does not present unified findings. In one study, the results show that delayed feedback is superior to immediate feedback. In the next study, the results show that immediate feedback results in greater learning.

Summary

The studies in this section presented research related to homework's relationship to learning, community college students, community college student success in mathematics, technology in teaching and learning, and feedback and learning.

The research related to homework and learning supported the completion of homework as a way to enhance learning. The studies on community college students

presented some of the challenges faced by today's students. Community college student success in mathematics was mainly focused on the developmental mathematics student. One notable result was that students who successfully remediate perform equally as well in college-level coursework as those students who were not required to take remedial coursework.

The technology in teaching and learning section presented a variety of studies aimed at the perceptions and use of technology by students and teachers. In addition, the presented studies confirmed that use of online homework systems is at least as effective as traditional textbook homework. The studies depicted in the feedback and learning section presented conflicting results when comparing immediate and delayed feedback.

In Chapter III, the research design is presented. Details of the setting and sample, methods, instrumentation and materials, and analysis are provided.

CHAPTER III

METHODOLOGY

The purpose of this study was to determine the impact that an online homework system had in a face-to-face community college mathematics course. Of particular interest were the effects upon student achievement and the manner in which students perceived the online system. Differences in academic achievement between online homework and textbook homework students were compared. In addition, the perceptions of online homework students were measured through surveys and a focus group interview. The major areas of this chapter include: the setting and sample, methods, instrumentation and materials, and analysis.

Setting and Sample

The college in the sample is located in the Central Valley of California. In the 2010/2011 academic year, there were 18,198 students enrolled with just under 10,000 full-time equivalent students (Merced College, 2012). The student ethnic composition was as follows: 45.9% Hispanic, 30.7% White, 0.9% Asian, and 0.5% African American (Merced College, 2012).

The population from which the sample was selected consisted of all Intermediate Algebra students enrolled at the community college involved in the study in the fall of 2011 semester and the fall of 2012 semester. During each of the fall 2011 and 2012 semesters, there were approximately 1,000 students enrolled in Intermediate Algebra (Merced College, n.d.).

Students enroll into Intermediate Algebra by either being placed into the course after taking a mathematics placement test or after successfully completing the prerequisite course of Beginning Algebra. Students register themselves into courses by reading the course schedule. They can do so online or in person. The course schedule identifies whether a course will be taught with textbook homework or online homework. Students self-select into their chosen section of Intermediate Algebra.

The course sections selected for this study included two online homework sections from the fall of 2011, one online homework section from the spring of 2012, three online homework sections from the fall of 2012, and two textbook homework sections from the fall of 2012. The reason this particular sample was selected out of the possible sections was that the fall 2011 online homework sections and the fall 2012 textbook homework sections were taught by the same instructor, with the same content, and the same exams. The instructor specifically designed each section so that the homework assignments would cover the same concepts and each exam would be identical. The fall 2011 sections used online homework, and the fall 2012 sections used textbook homework. The other online homework sections from the fall of 2012 were selected because the instructors agreed to participate.

For the purpose of determining differences in academic achievement, the total sample included 128 students out of an original 177 enrolled students in the sections. The 128 students were selected because they completed the pre-test, submitted at least one homework assignment, and took the final exam. Of this sample, 62 students used online homework and 66 students used textbook homework. For the purpose of

determining the manner in which students used and perceived the online homework system, online homework surveys and focus groups were used. The surveys provided a sample size of 176 students, where 49 students were from the fall of 2011, 38 students were from the spring of 2012, and 50 students were from the fall of 2012.

There were three focus groups conducted. Focus Group #1 included six online homework students who had completed Intermediate Algebra in the fall semester of 2011 and spring semester of 2012. The other two focus groups included online homework students who were enrolled in Intermediate Algebra during the fall semester of 2012. Focus Group #2 included three students, while Focus Group #3 included four students. Focus group participants indicated their willingness to volunteer as a response to one item on the online homework survey.

Research Methods

In order to answer the research questions of the study, a mixed-methods design was used. The participants in the study were community college students enrolled in Intermediate Algebra. For the measure of online homework's effect on academic achievement, the sample included two sections of Intermediate Algebra from the fall of 2011 and two sections of Intermediate Algebra from the fall of 2012. Students in the fall 2011 classes used online homework, while the fall 2012 classes used textbook homework. All sections were taught by the same instructor, using the same exams, class lectures, course pacing, and assigned problems.

A nine-question multiple choice pre-test was administered to the two participating fall 2011 online homework sections at the beginning of the second week

of school. The pre-test was composed of questions used on the prerequisite course, Beginning Algebra, final exam. The pre-test was administered during a regular class session, which gave students about 45 minutes to complete the instrument. The students were encouraged to perform as well as possible. As an incentive, students could earn points which were added to their final exam scores. For every correctly answered question on the pre-test, students were awarded 1/3 of a percent for up to a total of 3%. For example, if a student correctly answered 3 questions, he or she would earn an extra 1% added to the final exam percentage. The score on the pre-test was included in the study. The scores on the pre-test ranged from 0 to 9, where scores were determined by feeding answer sheets through a Scantron machine. No partial credit was given on test items. The same nine-question pre-test was administered to the two participating fall 2012 textbook homework sections at the beginning of the second week of school. The students took the test in class, were given the same amount of completion time, and received the same incentive as the fall 2011 students.

Surveys were distributed to the two fall 2011 online homework sections in order to measure student perceptions and use of the online homework system. A revised set of surveys was administered to Intermediate Algebra students in the spring of 2012 and the fall of 2012 in order to gather additional information about student perceptions and use of the online homework system. Online homework students from the fall 2012 semester were not taught by same instructor as the fall 2011 and spring

2012 students. In all semesters, students were given a 10-minute time allotment in class to complete the surveys.

Three student focus groups were established as a way to more fully understand the student perceptions of and use of the online homework system after analysis of the online homework survey. As suggested by Liamputtong (2011), the optimal group size was designated to be from 6-8 people and would last for approximately one hour. The purpose of the focus group was to provide students the opportunity to discuss their experiences with the MathXL system. Follow-up questions derived from the online homework survey results could elicit more information from students. In addition, discussion in a group setting might encourage students to discuss items that they did not think to include in the written survey. Flick (2008) indicated that focus groups can provide valuable information. While the surveys may provide the perspective of the individual, a focus group can provide results at a different level through group interaction.

Based upon the results of the fall 2011, spring 2012, and fall 2012 surveys, questions were developed for the focus group. The first focus group was composed of six Intermediate Algebra online homework students enrolled during the spring 2011 and spring 2012 semesters. All of the students had had taken Instructor #1. The second focus group was composed of three Intermediate Algebra online homework students enrolled in the fall of 2012 with Instructor #3. The third student focus group was composed of four Intermediate Algebra online homework students enrolled in the fall of 2012, where two were enrolled with Instructor #2 and two with Instructor #4.

All students who participated in the student focus groups were provided incentive to participate through promise of a $10 Starbuck's card. According to Flick (2008), focus groups should be carefully selected, depending upon the goal of the research. Because the focus group involvement was voluntary, the group was composed of those who agreed to participate. Students participated in an hour-long session where they were guided to more deeply describe their perceptions and experiences with the online homework system.

In order to add an additional perspective to the study, a focus group of Intermediate Algebra faculty was conducted. The group consisted of those faculty members who had used online homework in their face-to-face Intermediate Algebra courses. An invitation was sent to all Intermediate Algebra instructors who had used online homework in their courses. Those who were interested in participating met for a one hour discussion. Instructor perceptions of the online homework system were discussed. The size of the focus group could have been as high as 14 instructors. Because of instructor availability and willingness to participate, there were a total of 12 instructors who participated.

Approval from the institutional review board of the participating college and California State University, Stanislaus was received. Permission was obtained to utilize archival data from the fall semester of 2011, which included student grades and student survey results. In addition, permission was obtained to gather data from the fall 2012 semester, which included student grades, student survey results, and a focus group.

All Intermediate Algebra sections included in the treatment and control groups were taught during an 18-week fall semester session. Each class meeting lasted 50 minutes and met four days per week. The two online homework sections met at 9:00 a.m. and 10:00 a.m. The two textbook homework sections met at 9:00 a.m. and 10:00 a.m. The format of the classes was the same. The instructor answered student homework questions for no longer than 10 minutes at the beginning of each class. The remaining 40 minutes were dedicated to the lecture. Students in each section took the same number of exams, which included five tests and a final exam. Students in each section attended a lecture and were assigned a related homework assignment, which was expected to be finished by the next class meeting.

Treatment Group

In the fall semester of 2011, students from two sections of Intermediate Algebra participated in the study. The students were required to purchase a subscription to MathXL, which is an online homework system that accompanies the textbook *Beginning & Intermediate Algebra*, Fourth Edition, by Elayne Martin-Gay (2009). If students purchased a new textbook, MathXL was provided at no additional cost. If students purchased a used textbook or opted not to purchase a textbook, they had to pay for a MathXL access code at the price of $50 for a 12-month subscription or $82 for a 24-month subscription.

Fifty-two students participated in the online homework group. Student homework assignments were developed from section problems found in MathXL. The problems were assigned so that they corresponded to the same problems as found

in the textbook. Students were expected to have each assignment completed by the next class session; however, the students were able to complete homework up to three school days after the initial assignment. The length of time for completion of the assignment was determined to be suitable by the instructor because it required students to complete their homework in a timely manner and allowed students enough time to access the online system at the college, if they lacked access at home.

Homework problems were provided within MathXL. Students would work the problems with paper and pencil and then submit their answers to the system. MathXL responded as to the correctness of the student submissions. Students were given three attempts to get the answer correct. If students required assistance, they were able to seek help from the following options: *Help Me Solve This*, *View An Example*, *Textbook*, *Video*, and *Ask My Instructor*. If students were not able to submit a correct answer within three tries, they were permitted to attempt a new problem. Students could make as many attempts as necessary in order to ensure a correct answer. Students received immediate feedback on every problem and were able to have access to their homework scores at all times. Student homework scores were entered into their final grade according to the percentage of correct responses, which was provided by MathXL.

Control Group

Two sections of Intermediate Algebra from the fall semester of 2012 participated in this study as the control group. The students were required to purchase the textbook *Beginning & Intermediate Algebra*, Fourth Edition, by Elayne

Martin-Gay (2009). Student homework assignments were developed from section problems found in the book. When an assignment was given, the expectation was that it would be completed by the next class session; however, the students were permitted to turn in assignments up to three days after the assignment date.

The sample of 66 students representing the textbook homework group took the pre-test, turned in at least one assignment, and took the final exam. Students were able to check their answers in the back of the book, since most of the assigned problems had solutions provided. For those problems without provided solutions, students were given the correct solutions during the next class meeting. Student homework scores were determined by the instructor who graded according to completeness as opposed to correctness.

Instrumentation

Pre-test

The nine-question pre-test consisted of multiple choice questions, which were used to measure student learning in the prerequisite course, Beginning Algebra. The test was scored according to correct answer, where possible scores ranged from 0 to 9. No partial credit was given. In order to test for reliability of the instrument, a Cronbach Alpha test was conducted. The value was $\alpha = .71$. The pre-test was developed by faculty from the Mathematics Department at the participating college. The content validity of the instrument is supported through the manner in which the pre-test was developed. Instructors who taught Beginning Algebra developed the pre-test so that measured what the group considered to be crucial concepts in Beginning

Algebra. On this test, students were also asked to indicate whether they placed into the Intermediate Algebra course by successful completion of Beginning Algebra or through the placement test.

Final Exam

The final exam consisted of 17 multiple choice questions. The reliability of the instrument was established through a Cronbach Alpha calculation, where the value was $\alpha = .72$. The first nine questions represented concepts that were covered throughout the semester. The content validity of the first nine questions of the was established through discussions among Mathematics Department faculty. The final eight questions represented concepts covered in the last two weeks of class. While only a single instructor developed the questions, other members of the Mathematics Department agreed that the questions were representative of the material covered in those remaining weeks of the semester, establishing the content validity of the items. The questions covered mainly exponents and logarithms. The exams were graded using a Scantron machine in order to achieve reliability in scoring.

Fall 2011 Online Homework Survey

A survey was developed in order to determine how students used and perceived the online homework system. The survey included a total of 11 items (see Appendix A). The first nine items asked students to select the best answer from among the choices. Likert scale questions were provided on questions one through seven. Values from 1 to 5 were assigned to responses such as disagree, somewhat disagree, neutral, somewhat agree, and agree. On items eight and nine, students

answered yes or no. Item one, item two, and item three measured student satisfaction with the online system. Item four, item five, and item nine reported student use of the system. Item six and item seven measured student perceptions of the manner in which instructors used the online system. Item eight measured a student's previous use of online homework in other mathematics classes. At the end of the survey, students were provided with two open-ended items designed to identify student likes and dislikes of the online homework system. Reliability of items one, two, and three used to measure student satisfaction with the online system was established through a Cronbach Alpha calculation, which was $\alpha = .85$. Instructors in the Mathematics Department who used online homework in their face-to-face courses contributed to development and revision of the survey, establishing content validity of the instrument.

Spring 2012 Online Homework Survey

Modifications were made to the fall 2011 survey and distributed to students in one section of spring 2012 Intermediate Algebra (see Appendix B). The question related to whether instructors used MathXL during class was removed. One item was added in order to find volunteers for the student focus group. A second item was added in order to try to get students to further explain their level of usage with respect to the help buttons.

Fall 2012 Online Homework Survey

Modifications were made to the spring 2012 survey and the survey was distributed to online homework students in the fall semester of 2012 (see Appendix

C). Students were given an opportunity to more specifically describe their usage of the MathXL help options.

Student Focus Groups

Each focus group consisted of Intermediate Algebra online homework students. Questions and topics discussed during the first one hour meeting were derived from themes found in the online homework surveys. Questions for the second focus group were similar to the first focus group, but were slightly modified based on the discussion that occurred during the first focus group. The questions used during the third student focus group were modified according to the discussion that occurred during the second focus group. The dates and times were selected according to the participants' schedules. The first and third focus groups were conducted in a college conference room, while the second focus group was conducted in a conference room located at one of the college's satellite campuses. Participants gathered around a large table and discussed the topics as prompted by the researcher. The researcher guided the conversation in a way that permitted students to discuss their usage and perceptions of MathXL.

Instructor Focus Group

The focus group consisted of Intermediate Algebra instructors who offered online homework in their face-to-face courses. Questions and topics discussed during the one hour meeting were derived from the online homework surveys and the student focus groups. The date and time were selected in order to include as many instructors as possible in the focus group. Participants gathered around a large table and were

able to discuss the topics as prompted by the researcher. The researcher guided the conversation in a way that permitted instructors to discuss their own perceptions of and student perceptions related to use of the online homework system.

Data Analysis

In order to determine the impact of an online homework system in a face-to-face class, three research questions were developed. The research question related to determining whether differences in academic achievement existed was addressed through a quantitative approach. Sub-questions were examined in order to control for certain conditions. Each of the questions had accompanying hypotheses which required testing.

H1: There is no statistically significant difference in academic achievement between Intermediate Algebra students who use online homework and those who use textbook homework.

An independent *t*-test was performed in order to measure for differences in academic achievement between online homework and textbook homework students. The independent variable of homework type was categorical, online homework or textbook homework. The dependent variable of academic achievement was measured with the final exam score, which was a score between 0 and 17.

$H1_A$: There is no statistically significant difference in academic achievement between Intermediate Algebra students who use online homework and those who use textbook homework when controlling for beginning academic achievement.

An ANCOVA was performed in order to explain differences in academic achievement between online homework and textbook homework students, while controlling for beginning academic achievement level. The independent variable was homework type. The covariate of beginning academic achievement level was measured by a pre-test, which contained nine questions representing a review of material from Beginning Algebra. The dependent variable was the number of correct answers on the 17 questions of the final exam.

$H1_B$: There is no statistically significant difference in academic achievement between Intermediate Algebra students who use online homework and those who use textbook homework based on the number of course attempts.

An ANCOVA test was performed in order to explain differences in academic achievement between online homework and textbook homework students, while controlling for the number of course attempts. The independent variable was homework type. The covariate of number of course attempts was determined from student transcripts. The number of course attempts was a number 1 or greater. Only students who were enrolled after the third week of classes were included. The dependent variable was the number of correct answers on the 17 questions of the final exam.

$H1_C$: There is no statistically significant difference in academic achievement between Intermediate Algebra students who use online homework and those who use textbook homework based on how students were placed in course (placement test versus passing previous college math course).

Two-way ANOVA tests were performed in order to explain differences in academic achievement when considering homework type (online versus textbook) and manner of course placement. The independent variable of homework type was categorical, online or textbook. The independent variable of course placement was categorical, with course placement determined by students either placing into Intermediate Algebra via the mathematics placement test or enrolling after successfully completing the prerequisite Beginning Algebra. Course placement was determined through a question answered by students on the pre-test. The manner of course placement was self-reported by students when they completed their pre-test. The dependent variable was the number of correct answers on the 17 questions of the final exam.

The second research question addressed student use and perception of the online homework system. The question was explored using the online homework surveys and the student focus groups. The survey provided student self-reports regarding homework completion and use of the help options in the MathXL system. The open-ended responses also permitted students to report how they further used the system. The focus groups provided another opportunity for students to describe how they used and perceived the system.

The third research question focused on instructor perceptions of the online homework system. The question was investigated through a faculty focus group. The responses from the student surveys and student focus groups were used to develop discussion items for the faculty focus group.

Summary

The setting and sample, methods, instrumentation, and analysis used in this study were presented. In order to measure student perceptions, surveys and focus groups were developed. Multiple analyses were carried out in order to measure for differences in student achievement. A faculty focus group was developed in order to determine instructor perceptions of the online homework system.

CHAPTER IV

RESULTS

In order to determine the impact of an online homework component in a college mathematics course, student achievement was analyzed and student and instructor perceptions were gathered. Analyses were conducted for possible differences in academic achievement between online homework students and textbook homework students based upon a variety of conditions. Student perceptions were gathered through student surveys and focus groups, while instructor perceptions were gathered through a focus group only.

What impact does an online homework component have in a face-to-face community college mathematics course?

Research Question 1

What is the difference in academic achievement between Intermediate Algebra students who use online homework and students who use textbook homework?

Hypothesis 1

There is no statistically significant difference in academic achievement between Intermediate Algebra students who use online homework and those who use textbook homework.

An independent-samples *t*-test was conducted to evaluate the hypothesis that there is no statistically significant difference in academic achievement between Intermediate Algebra students who use online homework and those who use textbook

homework. Table 1 shows the academic achievement means and standard deviations for each homework type.

Table 1
Means and Standard Deviations for Academic Achievement

Homework Type	*n*	*M*	*SD*
Online	52	12.27	3.12
Textbook	66	12.53	3.47

Levene's Test for Equality of Variances was not significant, $F(51, 65) = 1.51$, $p = .22$. Consequently, equal variances were assumed for the results of the independent-samples *t* test. The independent-samples *t*-test was not significant with $t(116) = -.42$, $p = .67$. This result suggested that students in the online homework group and the textbook homework group had measured academic achievement which was very comparable.

Question 1A

What is the difference in academic achievement between online homework and textbook homework Intermediate Algebra students when controlling for beginning academic achievement level?

Hypothesis 1A

There is no statistically significant difference in academic achievement between Intermediate Algebra students who use online homework and those who use textbook homework when controlling for beginning academic achievement.

A one-way analysis of covariance (ANCOVA) was conducted. The independent variable, homework type, included two levels: online homework and textbook homework. The dependent variable was academic achievement as measured

by the number of correct answers on the 17 questions on the final exam. The covariate was beginning academic achievement as measured by the number of correct answers on the 9 questions comprising the pre-test.

A preliminary analysis to evaluate the homogeneity-of-slopes assumption indicated that the relationship between the covariate and the dependent variable did not differ significantly as a function of the independent variable, $F(1, 114) = 1.75$, $p = .19$, partial $\eta^2 = .02$. Since the results of the homogeneity-of-slopes assumption were not significant, an ANCOVA was conducted. The ANCOVA was not significant, $F(1, 115) = .35$, $p = .55$, partial $\eta^2 = .001$. Table 2 displays the results of the ANCOVA.

Table 2
ANCOVA Results Examining Online and Textbook Student Performance on Final Exam after Controlling for Pretest Results

HW Type	*n*	*M*	M_{adj}	*SD*	*F*	*p*	η^2
Online	52	12.27	12.21	3.12	0.35	.55	<.01
Textbook	66	12.53	12.58	3.47			

Question 1B

What is the difference in academic achievement between online homework and textbook homework Intermediate Algebra students based on the number of course attempts?

Hypothesis 1B

There is no statistically significant difference in academic achievement between Intermediate Algebra students who use online homework and those who use textbook homework based on the number of course attempts.

An ANCOVA test was performed in order to explain differences in academic achievement between online homework and textbook homework students, while controlling for the number of course attempts. The independent variable was homework type. The covariate of number of course attempts was determined from student transcripts. The number of course attempts was a number 1 or greater. The dependent variable was the number of correct answers on the 17 questions of the final exam. A preliminary analysis to evaluate the homogeneity-of-slopes assumption indicated that the relationship between the covariate and the dependent variable did not differ significantly as a function of the independent variable, $F(1, 124) = 0.27$, $p = .60$, partial $\eta^2 = .002$.

Since the results of the homogeneity-of-slopes assumption were not significant, an ANCOVA was conducted. The ANCOVA was not significant, $F(1, 125) = 1.11$, $p = .29$, partial $\eta^2 = .01$. Table 3 displays the means and standard deviations of academic achievement for each homework type when controlling for number of course attempts as well as the results of the ANCOVA.

Table 3
ANCOVA Results Examining Online and Textbook Student Performance on Final Exam after Controlling for Number of Course Attempts

HW Type	*n*	*M*	M_{adj}	*SD*	*F*	*p*	η^2
Online	62	13.73	13.77	9.01	1.11	.29	<.01
Textbook	66	12.53	12.51	3.47			

Question 1 C

What is the difference in academic achievement between online homework and textbook homework Intermediate Algebra students based on how students were placed in the course (placement test versus passing previous college math course)?

Hypothesis 1C

There is no statistically significant difference in academic achievement between Intermediate Algebra students who use online homework and those who use textbook homework based on how students were placed in course (placement test versus passing previous college math course).

A two-way ANOVA test was performed in order to explain differences in academic achievement when considering homework type (online versus textbook) and manner of course placement. The independent variable of homework type was categorical, online or textbook. The independent variable of course placement was categorical, with course placement determined by students either placing into Intermediate Algebra via the mathematics placement test or enrolling after successfully completing the prerequisite, Beginning Algebra. The dependent variable was academic achievement, which was measured by the number of correct answers on the 17 questions of the final exam. The means and standard deviations for academic achievement as a function of homework type and manner of course placement are presented in Table 4.

Table 4
Means and Standard Deviations for Academic Achievement Based Upon Manner of Placement

Homework Type	Placement	*n*	*M*	*SD*
Online	Placement Test	25	12.04	3.42
	Took Previous Course	27	12.48	2.86
Textbook	Placement Test	16	12.88	2.90
	Took Previous Course	50	12.42	3.65

The two-way ANOVA indicated no significant interaction effect between homework type and manner of course placement. In addition, there were no significant main effects. As a result, there were no follow-up tests conducted. Table 5 shows the results of the two-way ANOVAs.

Table 5
Two-Way ANOVA for Academic Achievement Based Upon Manner of Placement

Source	*F*	*p*	η^2
HWType	0.34	.56	<.01
Placement	0.00	.99	<.01
HWType * Placement	0.45	.50	<.01

Research Question 2

How do Intermediate Algebra students use and perceive the online homework system?

In order to answer this question, a combination of student surveys and student focus groups were used. Surveys were collected from a total of 176 students, from four different instructors whom each used the online homework system, over a three semester period. Table 6 provides a summary of instructors, semesters, and numbers of students for which the online homework surveys were administered.

Table 6
Student Survey Information

Instructor	Semester	*n*
Instructor #1	Fall 2011	49
	Spring 2012	38
Instructor #2	Fall 2012	27
Instructor #3	Fall 2012	35
Instructor #4	Fall 2012	27

Survey items were analyzed using means, percentages, and frequencies. Table 7 shows the means for seven of the survey items. The last item in the table was not included on the surveys distributed in the classes of Instructor #1. The possible range of means was a number from 1 to 5, where higher means represented more positive student perceptions.

Table 8 presents the results of three survey items. The first and third items represent frequency of responses, while the second item represents the percentage of students who ranked each item as their top choice. The second survey item was not included on the surveys distributed by Instructor #1. The third survey item was excluded from the surveys distributed by Instructor #2, Instructor #3, and Instructor #4. Table 9 displays the frequencies for two free response items from the student survey.

Table 7
Means for Math C Survey Results by Instructor

Survey Item	Overall	#1 *n*=87	#2 *n*=27	#3 *n*=35	#4 *n*=27
MathXL online homework was more helpful than textbook homework.	4.38	4.49	4.63	4.11	4.56
MathXL online homework was easy to use.	4.30	4.45	4.56	4.00	3.92
If I had to take another math class, I would like to use MathXL.	4.38	4.49	4.59	4.23	4.00
I used the help buttons (*Help Me Solve This*, *View an Example*, *Video*, *Textbook*, and *Ask My Instructor*) when I needed help.	4.72	4.77	4.81	4.71	4.48
My professor gives us enough time to complete the online homework.	4.76	4.89	4.89	4.60	4.44
I complete my assignments on time.	4.44	4.39	4.59	4.49	4.41
How much do you use the help options?					
Help Me Solve This	3.30	N/A	3.00	3.34	3.56
View an Example	4.42	N/A	4.63	4.69	3.85
Video	2.01	N/A	2.19	1.97	1.89
Textbook	1.89	N/A	1.85	2.03	1.74
Ask My Instructor	1.79	N/A	2.30	1.37	1.81

Table 8
Frequencies for Math C Survey Results by Instructor

Survey Item	Overall	#1 *n*=87	#2 *n*=27	#3 *n*=35	#4 *n*=27
I have used online homework in other math classes.	40%	35%	67%	37%	40%
Use the numbers 1 through 3 to rank order the following reasons you chose to take this class section, where 1 is the main reason.					
Convenient Time	48%	N/A	40%	43%	64%
Online Homework	15%	N/A	16%	20%	8%
The Professor	36%	N/A	44%	37%	28%
I use the help options (*Help Me Solve This*, *View an Example*, *Video*, *Textbook*, and *Ask My Instructor*) on every problem.	31%	31%	N/A	N/A	N/A

Table 9
Frequencies for Math C Survey Results Examining Likes and Dislikes about MathXL

Survey Item	Overall	#1 *n*=87	#2 *n*=27	#3 *n*=35	#4 *n*=27
Explain what you like best about MathXL.					
Help Options	115	47	25	26	17
Easy to Use	22	12	5	3	2
Wrong Answer Do-Over	17	9	2	4	2
Immediate Feedback	16	5	5	5	1
Less Paper Hassle	12	6		1	5
No Textbook to Manage	9	2		3	4
Additional Practice Problems	2	2			
Helps when Absent from Class	2	2			
Cheaper than a Textbook	1		1		
Study Plan	1		1		
Reminders about Due Dates	1		1		
More Interactive than Textbook	1		1		
Explain what you like least about MathXL.					
System Picky about Answer Format	43	24	4	7	8
Time Consuming	16	5	2	3	6
Access Issues	11	6	1	3	1
Graphing Tools Difficult to Use	8	1	1	1	5
MathXL Examples Different from Class	3	3			
Site Occasionally Down	3	3			
Prefer Textbook Homework	3			2	1
Videos Not Offered for Every Problem	2	2			
Correct Homework Does Not Equal Passing	2	2			
Typing in Answers	1	1			
Less Problem Variety than Textbook	1	1			
One Approach to Solving	1	1			
Too Long for *Ask My Instructor* Response	1	1			

In addition to surveys, student perceptions about the MathXL system were gathered through three focus groups. The first student focus group was composed of six students who had used MathXL in a face-to-face class and had successfully completed Math C within a one-year time period. All of the students were prior students of Instructor #1. The focus group was conducted in a conference room at the

main college campus. The questions for the focus group were developed based on responses gathered from the student surveys. Questions were modified or added during the focus group meeting in order to better gather student responses.

The second student focus group was composed of three students who, at the time of the focus group, were using MathXL in a face-to-face class. All of the students were students of Instructor #3. The focus group was conducted in a conference room at a satellite campus of the main college. The questions for the second focus group were modified as a result of responses from the first focus group. In addition, the set of questions designed for the second group were modified throughout the discussion in response to student comments.

The third student focus group was composed of four students who, at the time of the focus group, were using MathXL in a face-to-face class. Two of the students were students of Instructor #2, while the other two were students of Instructor #4. The focus group was conducted in a conference room at the main college campus. The questions for the third focus group were modified as a result of the first and second focus groups. In addition, the set of questions designed for the third group was modified throughout the discussion in response to student comments.

Student discussions from the three focus groups were analyzed in order to determine emerging themes. The main items of discussion included when and where students completed their homework, whether they would have chosen MathXL if given a textbook option, how their written homework was affected by MathXL, how their MathXL experience differed from prior textbook experiences, how MathXL

helped with learning, which MathXL help options they used, the negative aspects of MathXL, the amount of time necessary to complete MathXL assignments, and their desire to continue using MathXL in future math courses.

Students discussed when and where they completed their Math XL homework. Students completed their homework either in a college computer lab or at home. Students were asked if computer access at the college was reasonable. Students agreed that there were enough computer labs and plenty of lab hours to finish assignments at school. This was the case at both the main college and the satellite campus. Homework assignments were typically completed by students immediately after they were assigned; however, some students who were provided access for longer time periods tended to do their assignments far after the assignment had been discussed in class.

Students discussed whether they would have chosen to use MathXL if they had been given the choice between MathXL and a textbook. Most of the students would have selected a textbook over MathXL. Students identified the additional cost of MathXL and the fear of the unknown system as being reasons that they would have opted for the traditional textbook. In addition, the benefits of MathXL were unknown to them at the time they would have been asked to decide between the two options. For those students who bought a new textbook, the software was included at no additional cost. The additional cost mentioned by students was related to the cost of purchasing the MathXL software beyond the cost of a used textbook.

Students were asked to describe how their written work was affected by using MathXL. The response from students was mixed. Many of the students prepared their work in the same manner as if it had been completed using a textbook. They wrote down problems and showed corresponding work either on loose leaf paper or in journals. There were some, however, who mentioned that their work was completed on a physical whiteboard, where students used whiteboard markers and an eraser as they worked through problems. Using the white board left no record of their work after they submitted their answers to MathXL. Others completed their work on scratch paper, where there was no recognizable organization. Using scratch paper did not permit students to review their work when mistakes had been made or in preparation for an exam. Most students indicated that they showed fewer steps as a result of their instructors not reviewing their written work.

Students indicated that their instructors did not collect paper homework if they were using MathXL. They were only required to input answers into the MathXL system. Students discussed whether turning in supporting paperwork for the MathXL work would be beneficial for students. Those who completed their work in an orderly manner thought that collected paper homework would be better for those students who did not keep an orderly record of completed work. They felt that students would be more careful to show the proper steps if their instructors were going to review the paper homework. Those who did not keep a record of written work felt that collecting paper work would not be helpful for students.

Students described how their experience with MathXL homework differed from their experience with textbook homework in prior classes. The students identified their experience with MathXL to be superior to the textbook because MathXL provided examples for every problem, easily accessible help, instant feedback, practice problems, and multiple attempts. In addition, MathXL helped students to stay organized and did not require students to carry around a heavy textbook. The students described the examples provided in textbooks to be inadequate because the examples often did not correspond to the problems on which students were struggling. In contrast, MathXL provided corresponding examples for every problem.

According to focus group participants, the help provided by MathXL was varied and immediately available. Students appreciated the multiple help options. Most students described *View An Example* and *Help Me Solve This* as the most useful, but also identified *Video* and *Textbook* help options as being helpful. They appreciated the immediate help provided by MathXL. Students especially liked the instant feedback. Their work was immediately identified as being correct or incorrect. Students mentioned that when they received feedback that they were incorrect, they would use the help options until they were able to successfully complete the problems.

MathXL was identified as being able to provide unlimited practice problems. When students completed a problem, they could continue practicing the same problem by asking MathXL for a new problem. This permitted students to practice

similar problems with different numerical values. Students described this as being a confidence booster, especially when problems were particularly challenging. Students liked how MathXL would let them redo problems that they had done incorrectly. They appreciated that they could get perfect scores on their homework assignments. Students mentioned that MathXL helped them to stay organized. They were given prompts about due dates and had immediate access to their assignments as soon as they logged into MathXL. Their homework scores were always up-to-date and available.

Students described how MathXL helped with learning. They indicated that MathXL provided help when problems were a challenge. In addition, students were given immediate feedback as to the correctness of their answers. Students immediately knew if they needed to continue working on particular problems. By receiving feedback related to correct answers, students identified being confident in moving forward on the material. A number of students pointed out that MathXL filled in any knowledge gaps. While students agreed that most instructors fully taught each lesson, the ability of each student to learn all of the concepts during class differed from student to student.

Students identified the help options they used most often. The students mainly used *View an Example* and *Help Me Solve This.* They liked *View an Example* because it showed them the exact steps necessary to solve the type of problem on which they were stuck. The provided help was specific for each problem. The only difference between the example and the given problem was that different numerical

values were used. Students said that *Help Me Solve This* provided prompts, which helped students work step-by-step through the actual problem on which they were stuck. Then a new problem containing different numerical values would be provided. Students identified *Video* and *Ask My Instructor* to be the least used. Students believed that the videos were particularly helpful when students had to miss class and that *Ask My Instructor* was useful when the help buttons were not quite enough.

Students identified the negative aspects of using MathXL. Some students mentioned that test-taking was a challenge because with MathXL homework they received immediate feedback on every problem. While doing homework, this gave them confidence to move onto the next problem. There was no immediate feedback provided during in-class exams. Some students mentioned that they had come to rely upon the feedback. A number of students indicated that their instructors used quizzes and test reviews which did not provide immediate feedback. They believed that this use of quizzes and test reviews helped them to better transition to exams where no feedback was provided.

Students identified the answer format required by MathXL to be a challenge. The format for inputting answers was very specific and often resulted in students missing problems for technical reasons. Students mentioned that for many problems they were required to submit only the necessary numerical values, but there were some that required additional notation. For example, when inputting the solutions to equations, MathXL did not require students to write the variable in the solution. In contrast, when students were asked to input the coordinates of an ordered pair,

MathXL required the coordinates and the surrounding parenthesis. Students noted that when their answer was identified as incorrect by MathXL, they would think that they had done something wrong while solving. Instead, the issue was sometimes related to the final input.

The graphing processes within MathXL were also a challenge for students. In many problems, students would select the correct graph from a set of multiple choice options. In another section, the students would be required to graph using the graphing tools. A number of students indicated that their instructors had not reviewed the MathXL graphing input process. Without instructor guidance, students would struggle to correctly input the graphs. This resulted in frustrated students who often were not able to complete their homework.

Students who sought help with MathXL homework in the Math Lab found it difficult to find instructors who knew how to use the MathXL system. The Math Lab is a place where students can receive math help from a math instructor. Students reported, while working in the Math Lab, that they would seek both problem help and MathXL input help from Math Lab instructors. While Math Lab instructors were able to help with issues related to math problems, they often were not able to assist with the answer input required by the MathXL system. This would leave students feeling frustrated.

While feedback about the help buttons was mainly positive, there were also some negative aspects identified by students. Students complained that *Help Me Solve This* required them to work through the actual problem on which they were

stuck and then attempt a different one. They felt like they had to do two problems each time they selected this option. Students indicated that the *Video* help option did not provide a video for each problem. They had gotten used to receiving problem-specific help each time they were stuck.

Students also said that the MathXL help button explanations were often different from those they received in class. Students generally preferred the methods used in class and mentioned that MathXL occasionally asked for less or more steps than their instructor. In addition MathXL would occasionally use unfamiliar terminology. Student reaction was mixed as to whether a different approach to problem solving was a positive or a negative. Some students appreciated that multiple approaches gave them different ways to do the same problem. Other students perceived the multiple approaches to problem solving to be a hindrance in their learning. They felt that it was confusing to have the instructor explain problems one way, and then receive support from MathXL with a different method.

The students thought that integrating MathXL into the classroom lecture would be helpful. The instructor could point out the differences in approach in order to prepare students for the homework. Most of the students believed that different explanations were not as confusing as different expectations in the final form of answers. If instructors could show how to input answers, there would be less frustration when completing the homework. Students mentioned that if instructors could not incorporate MathXL into class every day, that the instructors could at least provide guidance when the input might be a challenge for students.

Students spoke about the amount of time they were given to complete MathXL assignments. They had anywhere from a few days to a couple of weeks to complete assignments. Students believed that their instructors typically gave them enough time. The only instance when time became an issue was when instructors assigned problems to be due the following day, which was not the norm. Students who lacked home access to MathXL found it a challenge to make it to a college lab in time to get the assignment completed in that short time period. This was especially true when students were expected to complete an assignment that would take longer than usual because of its complexity. Students who were given longer periods to submit homework admitted that procrastination was an issue. They had also heard from their classmates that waiting to do homework at the last minute was common. While students identified procrastination to be an issue, each of them appreciated the homework being available up to the test date so that they could attempt any problems they were unable to complete during prior homework sessions.

Students discussed their desire to continue using MathXL in subsequent math courses. They agreed that they would seek out math classes offering MathXL, but would select first by instructor. Ideally, the next math course would have the instructor they wanted with the option of using MathXL. Students mentioned that they would be nervous if MathXL were not offered in their next course, even if they did get their instructor of choice. They actually used words like intimidated, uncomfortable, and overwhelmed to describe their feelings.

Through student surveys and focus groups, it was revealed that students like MathXL. Students were able to easily identify the positive aspects of MathXL. While negative aspects of MathXL were noted, students were able to describe recommendations for instructors which might help to overcome those negative experiences.

Research Question 3

What are the perceptions of Intermediate Algebra instructors as related to the student perceptions of and their own experience with the online homework system?

In order to answer this question, a faculty focus group was conducted. Summarized results from the student surveys and student focus groups were presented to 12 faculty members of the Math Department for review and discussion.

Instructors discussed the student concern that the instructor response for the help option *Ask My Instructor* took too long. Instructors commented that students believe that the response should be instantaneous, as it is with the other MathXL help options. The group mentioned that instructors should warn students that responses to *Ask My Instructor* could take a day or more and should be the last resort if students are expecting instantaneous assistance. The instructors discussed how students often provide dummy emails to MathXL with first registering, email addresses that students do not actually check. Since responses to *Ask My Instructor* were emailed to that address, students often did not receive or read responses. The group agreed that students need to be warned that their input email addresses should be those they

actively check, especially if they want to receive help or homework update emails from their instructors.

Instructors discussed the idea that students frequently used the help options. Almost all students used *Help Me Solve This* and *View an Example*, where the second was the most popular. Instructors were varied in their responses to student use of help buttons. Some believed that students should freely use the help buttons, while others wanted to limit the amount of assistance students received. Those who wanted to limit student access to help buttons were concerned that students would become overly reliant upon the help provided by MathXL.

Some students reported that home internet access had been an issue. Even though most of the students accessed MathXL from a home computer, instructors acknowledged that it was important for students to have access to college computer labs. The group thought it would be wise to get a count of math students who required access to college computers in order to ensure that students would have continued campus computer availability.

Students typically completed assignments immediately after they were assigned, but some did procrastinate. This was especially true in courses where students were given a long time to complete assignments. Instructors had a mixed reaction to concerns over student homework procrastination. While instructors agreed that homework procrastination was detrimental, they wanted to ensure that students had enough time to complete assignments. One approach was to provide students a couple of days to complete each assignment, while another was to give

students a week or more to complete assignments. Whatever the approach, instructors reported that they were constantly trying new approaches to figure out what worked best for their students.

Of the 13 students asked, eight of them would have selected a textbook over MathXL if given the option. Most instructors made MathXL mandatory in their courses. While some believed that giving students the option to choose MathXL or textbook was important, they also believed that instructors should show how the program works and explain its benefits within the first day or two of the semester. Instructors did agree that students would probably choose a textbook, if the students were unaware of the benefits of MathXL. The entire group of instructors perceived the MathXL system to be more beneficial than a traditional textbook; however, a couple instructors felt that forcing students to use MathXL might result in student resentment and possibly lower achievement for those particular students.

Most students said that their written MathXL homework was as thoroughly complete as previous textbook homework; however, a fair number indicated that their written MathXL homework was unorganized. The students were unable to understand their own written work. The instructors showed concern regarding this issue. While most of them had tried various approaches to checking that students were writing the steps to homework problems, some admitted that they had not thought about this issue. A number of ideas were presented, including having students turn in homework packets and giving students quizzes to check that they were following the proper process for each problem.

Students commented that a down side to MathXL was that they had become accustomed to the constant feedback and that this made test-taking difficult because immediate feedback was lacking. All instructors acknowledged that they had this concern. Different recommendations for overcoming this challenge were discussed. One was to give weekly quizzes and test reviews, which provided no help or feedback. A second recommendation was for instructors to create additional homework assignments where feedback was lacking.

Students were concerned that Math Lab instructors were unable to assist them with the answer inputs required by MathXL. The instructors discussed ways in which this issue could be addressed. One approach was to inform the students as to which Math Lab instructors were familiar with the MathXL system. The other approach was to offer training for Math Lab instructors who were not familiar with the system. One last recommendation was for instructors to carefully monitor when the MathXL system required more difficult inputs, and then incorporate MathXL into the classroom discussion.

Many instructors believed that students were learning more with the MathXL system than with regular homework. While some contended that test scores were higher as a result of using the system, a number of instructors indicated that students had stopped asking questions about homework in the class session following the lesson. It was common for instructors to assign homework problems and field questions about those problems at the beginning of the next class.

Summary

The analyses completed to compare for differences in academic achievement between online homework and textbook homework students showed no differences between the two groups. The perceptions of students and instructors indicated that both groups believed that there were benefits to using the MathXL system. Even though both students and instructors could identify negative aspects with the MathXL system, they each had recommendations for overcoming the identified issues.

CHAPTER V

DISCUSSION AND RECOMMENDATIONS

Summary of the Study

The purpose of this study was to explore the impact that an online homework component had in a face-to-face community college mathematics course. The following questions were used to guide the research: What is the difference in academic achievement between Intermediate Algebra students who use online homework and students who use textbook homework? How do Intermediate Algebra students use and perceive the online homework system? How do instructors respond to student perceptions of the online homework system?

Student Academic Achievement

The first research question investigated whether there were differences in academic achievement between Intermediate Algebra students who used online homework and those who used textbook homework. Student Intermediate Algebra final exam scores were used as the measure of academic achievement. Students were assigned to one of two groups, online homework or textbook homework. An independent *t*-test was conducted and showed no significant differences between groups. This implies that the mean performance on the exam was similar for students in both groups.

Throughout the literature, there have been suggestions that online homework may be beneficial to special subgroups of students, such as those who are low achievers or those who have repeated the course. In order to more thoroughly

investigate possible differences in academic achievement between these groups, additional analyses were conducted. Differences in academic achievement between the online and textbook homework groups were examined while controlling for beginning academic achievement. Pre-test and final exams were administered to each group. After performing an ANCOVA, no differences in achievement were determined. This suggests that after controlling for the incoming achievement level, students performed equally whether they used online or textbook homework.

Differences in academic achievement were also studied between online and textbook homework students based upon the number of course attempts. An ANCOVA revealed no significant differences between online and textbook homework students, when controlling for the number of course attempts. This result indicates that no matter the number of course attempts, online and textbook homework students performed equally well.

One last comparison for student achievement was based upon the type of student placement into Intermediate Algebra. Students had either successfully completed the prerequisite Beginning Algebra course or they had placed into the course via the college placement test. A two-way ANOVA test was conducted and showed no significant differences in achievement between those who completed the prerequisite course and those who had placed via placement test. This implied that students who completed the prerequisite or placed into Intermediate Algebra showed similar academic achievement whether they used online or textbook homework.

After conducting four statistical analyses which compared student achievement for online and textbook homework groups, no differences in academic achievement were determined. The analyses do not promote one homework approach over another and do indicate that student achievement is no different for online homework students or textbook homework students. This suggests that instructors who are concerned about using online homework can be comforted in knowing that students perform equally well with respect to academic achievement, no matter the homework type.

Student Use and Perceptions of Online Homework System

In order to investigate how Intermediate Algebra students used and perceived the online homework system, student surveys and student focus groups were utilized. Surveys were collected from Intermediate Algebra online homework students in the fall of 2011, spring of 2012, and fall of 2012. A total of 176 surveys were collected. Students were enrolled with one of four instructors. Three student focus groups were also conducted, in which a total of 13 students participated. The focus group students were elicited from the students who submitted online homework surveys over the three semester period. Students provided feedback related to when and where they completed their online homework and the manner in which they utilized the MathXL system.

Students indicated that they completed MathXL homework assignments at home, in a college computer lab, or both. Those students who utilized college computer labs suggested that the college provided reasonable lab availability at both

the main college and the satellite campus. Most students suggested that they completed assignments as soon as they were assigned; however, some students indicated that they procrastinated, especially in cases in which the instructor gave lengthy periods of time for assignment completion.

About half of the focus group participants described their written MathXL homework to be similar to that of textbook homework completed in other math courses. These students kept a written record of problems and associated work on loose leaf paper or in a notebook. Students often referred back to their written work when studying for exams. The other half of focus group students kept no written record of their MathXL homework. There was no way the students could go back and find the work they had completed for each problem.

The students mentioned that their work would be different if they knew that their instructors were going to collect it. Even the students who kept written records of their work indicated that they tended to show fewer steps than with the work they had completed using a textbook. Some students believed that instructors should collect written work in order to ensure that students were following the expected processes, although the students who kept no written record of work thought that instructors should not collect written homework.

Students used the help options *View An Example* and *Help Me Solve This* more frequently than *Video, Textbook,* and *Ask My Instructor.* Both *View An Example* and *Help Me Solve This* provided students with examples that were very similar to the problem on which they were stumped. The reason students cited for

preferring *View An Example* over *Help Me Solve This* was that they could passively read through the process on *View An Example*, which featured a problem similar to the one students were tasked with solving. With *Help Me Solve This*, students were required to work through the actual problem with guiding prompts. The students would then be required to attempt another problem containing different values.

One survey item asked students about the frequency of help button usage. Of the 87 students who responded to this item, 31% indicated that they used the help buttons on every problem. This frequency indicates that a fair number of students did not even attempt a problem before they looked at the example, which could make transfer of knowledge to exams difficult.

Focus group students indicated that use of MathXL for homework was superior to textbook homework for a number of reasons. MathXL provided specific examples for every problem, gave immediate feedback as to the correctness of each answer, and permitted unlimited problem attempts in the case of incorrect answers. Students felt that MathXL helped with their learning. The help buttons allowed students to receive the necessary intervention in order to continue with their homework, giving them the confidence to move on when they encountered difficult problems. This was preferred to the delayed feedback they experienced with regular textbook homework. Students identified the capacity to practice multiple problems containing different values as being helpful in the learning process. When students encountered extremely difficult problems, they would redo that problem until they felt comfortable enough to move to the next problem.

Students identified a number of negative aspects regarding MathXL. The following were frequently cited or discussed: picky answer format was required by MathXL, graphing tools were difficult to use, Math Lab instructor support for the program was lacking, different solving techniques were presented by MathXL and instructor, and test-taking was a challenge because of student overreliance upon MathXL.

One important idea that emerged during the study was that of instructors making MathXL optional or mandatory. When the focus group students were asked if they would have voluntarily used MathXL, most would have selected a textbook. The reasons they gave were that the benefits of MathXL were unknown to them at the time they would have had to choose; and those purchasing used textbooks had to pay an additional price to access MathXL.

Most students in the study indicated they would seek out MathXL for their next math class. However, students commented that they would first seek a particular instructor over seeking MathXL.

Instructor Perceptions

A faculty focus group consisting of Intermediate Algebra instructors who used MathXL homework in a face-to-face classroom was conducted. A total of 12 instructors out of a possible 14 participated in the focus group. The instructors were presented a summary of the online homework surveys and student focus group comments for discussion.

Overall, the instructors believed that MathXL was good for their students. Many of the instructors reported the perception that their students had improved academically over the semesters as a result of instituting the MathXL online homework system. While none of them had completed a thorough statistical analysis, many had compared the exam means from semesters when they used textbook homework to those semesters with online homework. In addition, instructors interpreted the lack of student homework questions to indicate that students understood the material. It is possible that the lack of questions did not really mean the content was comprehended; it just meant that the MathLX system allowed students to complete the assigned homework.

Even though only a small number of students complained about the *Ask My Instructor* response being too slow, instructors commented that students expected the response to be as immediate as the MathXL help buttons were. Instructors also identified that their responses were sometimes sent to inactive email addresses that students had input when registering their MathXL license.

The instructors were not surprised that students reported heavy reliance upon *View An Example* and *Help Me Solve This*. The group was mixed about its concern over the students using the help buttons too often. Some instructors discussed ways in which they could limit the amount of student access to the help buttons.

MathXL access was a big concern for instructors. They thought it was important to ensure that students had access, especially since many instructors were making MathXL a requirement for the course. Beyond computer lab availability, this

concern also emerged in their discussion of ensuring Math Lab instructors were familiar enough with the MathXL system to provide support to students.

The instructors discussed the idea that students felt that the length for homework assignment submission was sufficient. Even though some instructors gave very lengthy periods for MathXL homework completion, they seemed unconcerned that students were often procrastinating. Some instructors wished to allow long periods of access to problems so that the students could continue to review. Instructors learned during the focus group that the assignments could continue to be accessible to students, even if the submission date had already passed.

Instructors were surprised that more than half of the focus group students would have selected a textbook, if given the option. While most of the focus group instructors made MathXL mandatory in their courses, there were a couple who believed that the traditional textbook option should remain available to students who have a fear of technology, to those who lack the financial resources to pay for the access code, or to students who prefer working with a traditional textbook.

The most surprising item to surface during the faculty focus group was that of how students completed and retained homework problems. Many of the instructors thought that students were writing down problems, showing the appropriate work, and keeping the assignments in some sort of order as they would with textbook problems. This was not the case for all of the students. Even the students who did have organized homework admitted to showing fewer steps than they had with textbook homework. A few instructors discussed how they had recognized that this

was occurring and had tried to spot check written homework to ensure that students were completing homework in a manner expected by the instructor. One suggestion was to assign homework grades based upon the MathXL system record and supporting written problems.

Instructors were surprised to find out that students were nervous about test taking as a result of receiving constant help and feedback on their MathXL homework. The group discussed ways to ensure that the students could receive the support of the MathXL system, but not become overly reliant upon it.

Most of the instructors believed that MathXL was beneficial to students and planned to make it a mandatory requirement for future Intermediate Algebra classes. Even though instructors lacked proof that MathXL resulted in greater academic achievement for students, the response from students and the instructors' own beliefs that students performed better appeared to be enough for the instructors to continue with its usage.

Discussion

In order to determine the impact that an online homework system had in a face-to-face community college mathematics course, student achievement, student perceptions, and instructor perceptions were examined. The face-to-face course Intermediate Algebra was selected for this study because there were many sections offered and multiple instructors using an online homework system, specifically MathXL.

The analyses conducted for differences in academic achievement showed no significant differences between online homework and textbook homework students. While some instructors at the college in this study suggested that their students' academic achievement had improved since instituting the online homework system, this perception was not supported in the multiple analyses conducted in this study for the students of one instructor.

With the help and feedback provided by the online homework system, it appears that the potential is there for the system to help students achieve at higher academic levels when compared to students who use textbooks. After all, the online system provides problems that are identical to textbook problems, yet the system also provides specific support for each problem and feedback on problem correctness. It is possible that the online system does provide the potential for greater student success, but studies have yet to confirm that online homework is indeed the better option. With improvements in academic achievement as the goal, it is worth the effort to discuss what about the online system and how the usage of the online system could contribute to more favorable academic results. The manner in which the online system is utilized by students and instructors is a good place to start.

Even though the online homework system provided students with easily accessible help and immediate feedback, the manner in which the students utilized the system may have hindered their learning. The literature supports that online homework may result in greater academic achievement for online homework students; however, if students required the assistance of the help buttons on every

problem, they may not have learned the concepts well enough to be retained for an exam. According to the results of a study performed by Goodman and Wood (2004), feedback specificity can help students with immediate performance, but may hinder their independent performance on exams. This might explain why students perceive the system to be beneficial. The easily accessible help permits students to successfully complete the homework assignments, but it may not provide knowledge that translates into later test performance.

Because students are only a click away from figuring out a challenging problem, they may not have to grapple with why they are making errors in the first place. They may, instead, be mimicking the provided process from the help button without internalizing the new knowledge. One student wrote on the survey that "The online homework is like false advertisement. You use *View An Example*, follow it and get the right answer, yet not understand how to do it on your own." Students may also perform this type of mimicry in the classroom. When an instructor models solving processes in class, students may mimic the process without experiencing the internal brain processing which translates to learning.

Different studies have supported online homework as promoting greater academic achievement in students; however, the manner in which academic achievement was measured in the studies is important. For instance, in a study performed by Mendicino, Razzaq, and Heffernan (2009), students who used online homework as compared to textbook homework performed better academically. In that study, the measure for academic achievement compared a pre-test and post-test

which were given one day apart. Math students in this study often waited three or more weeks for an exam after completing the first assignment in the set pertaining to the exam.

The help options offered by online homework systems provide formative feedback for students, which is important for the learning process. Hatziapostolou and Paraskakis (2010) describe formative feedback as necessary in guiding students through the learning process. The purpose of formative feedback is to support correct thinking, change poor processes, or clarify misunderstandings. If students rely upon help buttons for every problem, they are not giving themselves the opportunity to attempt problems independent of the MathXL system. The students may not experience the brain processing necessary to figure out a challenging problem and carry that process into the future.

Student reliance upon the help buttons and immediate feedback of the online system were discussed at length by the instructors. Recommendations were given that instructors should develop multiple opportunities for students to work through problems without the help buttons or immediate feedback. This could be accomplished through in-class work or quizzes and test reviews provided on paper handouts. Giving students a daily online assignment that contains two parts, one with the help options and immediate feedback and the other without, appears to be an idea that would give students the initial support they appreciate from the system but then challenge them to work independently like instructors ultimately expect. This type of approach is possible with MathXL, because the instructor settings can be modified.

Another consideration for improving academic achievement through MathXL is to limit the number of help options so that students must rely upon the one that requires the most student effort. Students described *Help Me Solve This* as requiring more effort than *View An Example*. *Help Me Solve This* prompts students to input answers at different steps in the problem, while *View An Example* provides a problem that is merely reviewed by students. The big difference between the two options is that with *Help Me Solve This*, students are actively involved; while with *View An Example*, students are passively involved. Students actually commented that *Help Me Solve This* required them to do each problem twice. Maybe this is what students actually need in order to truly learn how to do the problem.

An alternative idea would be to develop two-part assignments. The first part would permit unlimited student access to all help buttons and unlimited attempts at problems. The second part would be completed the next day with help options made unavailable and only a single attempt permitted. The immediate feedback related to problem correctness could also be provided in a summary form at the end of the assignment so that students are required to move forward in the assignment not knowing whether they had correctly completed each problem. This experience would closely resemble that of test taking.

MathXL allows for help buttons and problem attempts to be customized for each assignment. Instructors who wish to customize help buttons and problem attempts on a problem-by-problem basis must develop separate assignments.

Publishers should consider providing more flexibility with the system settings so that instructors can create assignments that will best benefit student learning.

Another consideration regarding students benefitting most from an online homework system is the manner in which an instructor incorporates the system into the class. Instructors who have more experience with the online system have a greater ability to use the settings of the system to best serve students. For instance, help buttons and the number of problem attempts may have been minimized by some instructors. Information related to instructor usage of the online homework system was not elicited from instructors during the study, but the faculty focus group indicated that instructors were utilizing the online system with different approaches. Instructors who reported higher class means after using MathXL may have provided students with only certain types of help options or a limited number of problem attempts. There may also have been opportunities in addition to MathXL so that students would benefit from MathXL support but also have practice without it, which would better replicate exam conditions.

An alternative to limiting the help options and problem attempts would be to educate the students on the most beneficial ways to learn using MathXL. Student learning preferences may be an important factor in offering a wide array of help possibilities. According to Constructivist Theory, learning occurs when students make sense of new information based on prior knowledge and their surroundings (Piaget, 1970). Because each student is unique, he or she may require different help options than another student. If instructors can assist students in understanding the

best way to utilize the system for learning, students may academically benefit. Instructors would need to either speak with students or provide a list of best practices related to the manner in which to best use the online system.

Given that most studies of online versus textbook homework have resulted in equal or greater academic achievement for online homework students, it is likely that instructors will continue to adopt the online homework systems. This is especially true because of the nature of today's students. They are used to getting immediate answers for any questions they have. Information is only a click away through an internet search. In the past, students had no choice but to rely upon a textbook or some other person for help. With the current available technology, students may find it challenging to seek out face to face help or wait for it from an instructor.

This sentiment was expressed by students throughout the study. Students preferred using an online homework system to a textbook. The students gave many compelling reasons why they preferred the online system. Students appreciated the easily accessible help provided for each problem and the immediate feedback related to answer correctness. A focus group student said, "It's like having a math instructor at home." The help provided by the online system gave confidence to students. Many of them reported that they felt confident in moving forward on homework with the online system because they could complete problems once given assistance by the help options. With a textbook, students reported that they often felt frustrated by problems because they could not access assistance to help them move forward in the assignment.

For instructors to truly know if students are following necessary processes and not skipping important steps, paper homework should be collected. Instructors should include the paper homework as part of the homework grade so that students will have inspiration for completing their assignments as expected by their instructors. A study performed by Ryan and Hemmes (2005) supports that students are more likely to complete homework to the satisfaction of the instructor when credit is being given for the assignment. Properly completed homework contributes to student achievement (Keith et al., 2004). Instructors need to see that work is done to an acceptable standard in order to ensure that students are getting the most from their homework.

Students identified procrastination to be a problem when instructors permitted a lengthy period of time for students to submit online assignments. Instructors learned that students could continue to access their homework even after the submission date. If students have not completed their math homework prior to the next class meeting, they have lost out on the advantages of problem practice. Practicing problems benefits students in learning subsequent concepts. Because the study of mathematics is linear, homework completion prior to learning new concepts is crucial. In a study performed by Orpen (1998), a significant negative correlation was found between procrastination and academic performance. Instructors should set due dates for online assignments just as they would for textbook assignments. With the availability of college computer labs, students lacking home access should be able to schedule time to complete their online homework. Even if students experience

time conflicts, online homework systems, particularly MathXL, permit students to print out homework problems and submit solutions at a later time.

The biggest frustration shared by students was related to the picky input format required by MathXL. Maybe the real issue is not that of a picky format requirement. Students notoriously identify their answers as correct, even though notation might be missing. For example, the coordinates of ordered pairs should be surrounded by parentheses. Students may believe that the parentheses are unnecessary; however, if students input an ordered pair without the parentheses, MathXL will identify their answer as incorrect. One reason students may have perceived MathXL to have picky input requirements is that students may have completed numerous math problems in the past without being corrected. If instructors have five classes with 40 students who receive 40 homework problems four days per week, it may be impossible for instructors to provide the written feedback necessary for students to realize their errors. What this means to instructors is that students need to understand that MathXL requires the input of answers to contain every part of the correct answer. Instructors must emphasize the correct form of answers at each opportunity. By working with students to identify common answer format errors during class time, instructors can help students to perform better mathematically and avoid having answers rejected by the MathXL system.

As a result of the online homework system, students no longer came to class with homework questions. Both instructors and students assumed that this was the result of students understanding the material. While that may be true, instructors

need to devote the beginning of class time to review prior material in order to ensure that students do understand the previous lesson. One way to do this is to have students work on problems that include concepts from the previous homework. The instructor could then have the students check their work. This would most likely lead to questions from students.

Instructors must be careful in using their instincts or feelings to determine if the online system is beneficial to students. While there appears to be promise in utilizing the online homework system, instructors should not assume that online homework is the cure for low student achievement. The manner in which the online homework system is utilized is likely important for student learning, and there are many other innovative teaching practices that could improve student learning. Instructors should continue to seek ways to improve student achievement. This can be accomplished through careful implementation of the online system by instructors or by using an altogether different teaching approach.

In the surveys and student focus groups, it was clear that students would choose a particular instructor before they would choose a course because it offered online homework. While students like the online system and wanted to use it again in subsequent math courses, they continue to place great importance on the instructor. Instructors should be aware that the human factor has a great impact upon students, and this, too, will affect their academic achievement.

Limitations of the Study

There were a number of limitations to this study. The manner in which academic achievement was determined, the manner in which students were selected for the study, and the manner in which students were selected for the focus groups could have impacted the results of the study.

When measuring for differences in academic achievement, a 17-question final exam was used for the academic achievement measure. The test was a multiple choice test, which may under-measure the knowledge of some students and over-measure the knowledge of others. Students received no partial credit and were not required to show written work. Students who made minor errors, but understood the concept, would have gotten the answer wrong. Students who made a good guess, but did not really understand the concept, would have gotten the answer correct. Whether this score is actually representative of a student's academic achievement is uncertain. One alternative to this instrument, which measures a student's achievement throughout the course, would be average exam score. Another alternative would be to provide questions which require students to respond to two or more multiple choice sub-questions. If students answer correctly for all sub-questions, the question would be scored as correct.

When measuring the students' beginning academic achievement level, a 9-question pre-test was used, which consisted of student learning outcome questions administered in the prerequisite mathematics course. Whether this score is representative of a student's beginning academic achievement is uncertain.

Alternative measures could be math placement score or average exam score from prerequisite course. While the tests are different, *z*-scores could be used in order to determine relative standing for beginning academic achievement.

Students were not assigned to the online homework and textbook homework groups through random sampling. Students enrolled in sections which identified the online homework requirement. It is difficult to know whether the students self-selected into an online homework class or chose the section for other reasons.

The analyses conducted for student achievement were performed with data from the students of only one instructor. Using additional instructors may have provided different results since an instructional approaches differ from instructor to instructor.

Student participation in the focus group was voluntary. Ideally, a mix of students who liked, were neutral, and disliked Math XL would have been more representative of the Intermediate Algebra students.

Recommendations for Further Study

A first recommendation is that further studies using more instructors and different math courses should be conducted. Analyses conducted with different instructors may have different results. It is possible that online homework provides a bigger boost for the students of some instructors more so than others because of different instructional approaches. There are many levels of algebra. Studying student academic achievement at the Pre Algebra and Beginning Algebra levels may show different results.

A second recommendation would be to look at how well students perform in a face-to-face class using an online homework component when they did or did not use an online component in their previous math course. This type of study might be helpful for students who struggle with math. It would beneficial to know if continued usage of the online homework system would help with completing subsequent mathematics requirements.

A third recommendation would be to study how well students do in the subsequent face-to-face mathematics classes using a textbook when they did or did not use an online component in their previous math course. This type of study would be useful, especially for students who were required to complete multiple levels of higher mathematics courses. If academic achievement is greater for the online homework or textbook homework students, this information could be used to better guide instructors and students in which type of homework to utilize in lower-level mathematics courses to better prepare students who require many mathematics courses.

A fourth recommendation would be to compare how MathXL students academically perform under different conditions as implemented by the instructor. Limitations on help button access, problem attempts, and feedback could be placed upon one class, while another class could have unlimited access. Shorter homework submission time periods could be set in one class, while another class could be given a week or longer to complete assignments. This type of study would be useful for instructors who are trying to develop assignments which most support student

learning. It would also help to establish an understanding of “best practices” with regard to use of MathXL.

A fifth recommendation would be to perform an in-depth study of how students actually use the online system. Students could report on usage items such as when they attempt assignments, how long it takes them to complete assignments, on which help options they rely, whether they attempt problems before seeking help, and how often they have to re-attempt problems. As an alternative to student self-reports, the MathXL system could provide instructors with the option of viewing student usage data. With either approach, the information could help publishers and instructors understand the manner in which students actually use the online system and could lead to more beneficial use.

A sixth recommendation would be to compare student usage and perceptions of the MathXL system based on whether their primary access was at home or on campus. Students could report items such as how much time they allow for assignment completion or what time of day they complete their assignments. This type of study might help instructors to better serve students depending upon their online homework access location.

A seventh recommendation would be to compare the retention rates of online homework students and textbook homework students. This study could help educators to determine if an online homework system should be required in a course. Even if the online homework system could be utilized to improve academic

achievement, it would be a poor choice if a significantly large amount of students were to drop the course because they did not like the system.

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APPENDICES

APPENDIX A

MATH C ONLINE HOMEWORK SURVEY FALL 2011

***Participation in this survey is completely voluntary. Your individual responses will be kept private. For 1 through 9, circle the best answer.**
Student Name _____Professor _____

1. **Math XL online homework was more helpful than textbook homework.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

2. **Math XL online homework was easy to use.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

3. **If I had to take another math class, I would like to use Math XL.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

4. **I used the help options (Help Me Solve This, View an Example, Video, Textbook, and Ask My Instructor) when I needed help.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

5. **I complete my assignments on time.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

6. **My professor has shown us how to input problems into MathXL.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

7. **My professor gives us enough time to complete the online homework.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

8. **I have used online homework in other math classes.**

Yes No

9. **I use the help options (Help Me Solve This, View an Example, Video, and Textbook) on every problem.**

Yes No

10. **Explain what you like best about Math XL.**

11. **Explain what you like least about Math XL.**

APPENDIX B

MATH C ONLINE HOMEWORK SURVEY SPRING 2012

*****Participation in this survey is completely voluntary. Your individual responses will be kept private. For 1 through 7, circle the best answer.

Student Name_____ Professor _____

1. **Math XL online homework was more helpful than textbook homework.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

2. **Math XL online homework was easy to use.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

3. **If I had to take another math class, I would like to use Math XL.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

4. **I used the help options (Help Me Solve This, View an Example, Video, Textbook, and Ask My Instructor) when I needed help.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

5. **I complete my assignments on time.**

All of the Time Most of the Time Half of the Time
Less than Half the Time Never

6. **My professor gives us enough time to complete the online homework.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

7. **I have used online homework in other math classes.**

Yes No

8. **I would be willing to participate in a group discussion about MathXL.**

Yes No

9. **How much do you use the help options (Help Me Solve This, View an Example, Video, and Textbook)?**

10. **How much did online homework influence your reason to take this class?**

11. **Explain what you like best about Math XL.**

12. **Explain what you like least about Math XL.**

APPENDIX C

MATH C ONLINE HOMEWORK SURVEY FALL 2012

*****Participation in this survey is completely voluntary. Your individual responses will be kept private. For 1 through 9, circle the best answer.

Student Name_____ Professor _____

1. **Math XL online homework was more helpful than textbook homework.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

2. **Math XL online homework was easy to use.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

3. **If I had to take another math class, I would like to use Math XL.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

4. **I used the help options (Help Me Solve This, View an Example, Video, Textbook, and Ask My Instructor) when I needed help.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

5. **My professor gives us enough time to complete the online homework.**

Agree Somewhat Agree Neutral Somewhat Disagree Disagree

6. **I complete my assignments on time.**

Almost Always Sometimes Every Once in a While Rarely Never

7. **How much do you use the help options?**

"Help Me Solve This"

Almost Always Sometimes Every Once in a While Rarely Never

"View an Example"

Almost Always Sometimes Every Once in a While Rarely Never

"Video"

Almost Always Sometimes Every Once in a While Rarely Never

"Textbook"

Almost Always Sometimes Every Once in a While Rarely Never

"Ask My Instructor"

Almost Always Sometimes Every Once in a While Rarely Never

8. **Use the numbers 1 through 3 to rank order the following reasons you chose to take this class section, where 1 is the main reason.**

_____Convenient Time _____Online Homework _____The Professor

9. **I have used online homework in other math classes.**

Yes No

10. **Explain what you like best about Math XL.**

11. Explain what you like least about Math XL.

12. If you would be willing to participate in a group discussion about MathXL and receive a $10 Starbuck's card, please fill out the provided card.

MathXL Focus Group

A 1-hour long focus group will be held in order to further discuss the MathXL online homework system. Eight students will be selected to participate in the discussion. The group will meet in the conference room Sci-227 at a time and date to be determined. As an incentive, those who participate will receive a $10 Starbuck's card.

If you would like to participate, please provide your name and a contact phone number and/or email address. Please give this card to your instructor when you turn in your survey.

Name _____

Professor_____

Student Phone Number _____

Student Email Address _____