ACADEMIC AND AFFECTIVE OUTCOMES OF COMPUTER-BASED INSTRUCTION ON DEVELOPMENTAL MATH STUDENTS

by

Eric M Kohler

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

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ABSTRACT

A study aligning the positive aspects of technological-based learning with the high-risk population of developmental math students was conducted to ascertain the academic and affective outcomes of an “emporium model” of instruction on students with a case history of mathematical failure. By running parallel course sections in both emporium (treatment) and lecture-based (control) formats at two comparable universities, the quasi-experimental research design examined the effects of instructional delivery on students’ academic completion rates, pass rates, and retention rates. Affective responses, namely mathematics anxiety levels and locus of control, were also studied using pre-post survey data to identify students’ within-group emotionality differences during the semester. Statistically, chi-squared analyses showed that emporium-model students completed and passed their courses at significantly lower rates than lecture-based control students. Likewise, a repeated-measures ANOVA indicated that teacher-led, lecture students reported a significant decrease in anxiety levels throughout the semester that was not evident among emporium-model students. No significant differences were found between the groups’ student retention rates and pre-post locus of control measures. The results reflect a disconnect between emporium-model pedagogies and developmental student aptitudes and attitudes. Developmental math programs should not underestimate the imperative role of a quality classroom teacher. Developmental programs must also use intensive academic and affective diagnostics to place students into the appropriate courses, taught by appropriately-matched models of instruction. Suggestions for further research are also included.

Keywords: emporium, developmental math, mastery learning, math anxiety, attribution

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List of Abbreviations

American College Testing (ACT)

Analysis of Covariance (ANCOVA)

Analysis of Variance (ANOVA)

Anxiety towards Teaching Mathematics (ATTM)

Assessment and Learning in Knowledge Spaces (ALEKS)

Career and Technical Education (CTE)

Cleveland State Community College (CSCC)

Computer-Assisted Instruction (CAI)

Educational Testing Service (ETS)

Full-Time Enrollment (FTE)

Institutional Review Board (IRB)

Locus of Control (LOC)

Mathematics Anxiety-Apprehension Survey (MAAS)

National Association of Developmental Education (NADE)

National Center for Academic Transformation (NCAT)

National Center for Education Statistics (NCES)

Northwest Regional Educational Laboratory (NWREL)

Scholastic Aptitude Test (SAT)

Unofficial Withdrawal (UW)

CHAPTER ONE: INTRODUCTION

Large-enrollment college courses are becoming increasingly populated with students who are ill-prepared to comprehend basic-skills curricula (Boylan & Bonham, 2007). As such, general education and developmental education courses are particularly prone to becoming collegiate bottlenecks, consistently hampered by high rates of student failure. The National Center for Educational Statistics [NCES] (2003) reported that upwards of 50% of developmental students fail during their first attempts at remedial writing and mathematics courses. Among community college students who originally enroll in a developmental math series, approximately 20% go on to complete a required college-level math course (Bailey, Jeong, & Cho, 2010).

Background

As a remedy to the pervasive lack of student understanding in developmental courses, many institutions have begun trending toward the area of computer-assisted instruction as a means of complementing, and in some cases replacing, current lecture offerings (Witkowsky, 2008). At the turn of the 21st century, almost one-third of institutions reported using technology as a hands-on instructional tool for on-campus remedial reading, writing, and math courses (NCES, 2003), with public two-year colleges being more likely than other institutions to offer remediation through a digitized forum of teaching and learning. Furthermore, organizational think-tanks such as the National Center for Academic Transformation (NCAT) have begun redesigning entire courses (rather than just individual classes or sections) to achieve better learning outcomes at a lower cost by taking advantage of the capabilities of information technology. Course redesign is not merely putting courses online; rather, it involves rethinking the way instruction is delivered to large-enrollment core courses in light of the possibilities that emerging technology offers (NCAT, 2011). Whole-scale course redesign allows officials in higher education the opportunity to enhance the collegiate learning experience with technological advances in instruction while effectively reducing the cost of education.

One of the hallmark pedagogical assets behind computer-assisted instruction is the computer's ability to manufacture vast reservoirs of test banks and problem sets, all while evaluating student performance in a relative blink of an eye. With this instantaneous feedback, teachers within the course-redesign structure have adopted the pedagogical standard of mastery learning. Advocated by Bloom (1968) since the 1960s, mastery learning emerged as one of the era's more prevalent educational theories due to its ability to increase student competence as well as confidence. Unfortunately, mastery learning activities proved to be cumbersome and time-consuming for both teachers and students, and were ultimately replaced with a standardized curriculum that emphasized breadth over depth (Guskey, 2007).

Recent advents in computer-assisted learning and instructional technology, however, have brought about a renewed resurgence in favor of mastery learning. In a whole-scale course redesign environment, as students navigate through the course at their own pace, they are restricted from advancing in the curriculum until they have successfully mastered the previous unit's material at a predetermined ability level (usually set between 70 and 80%). Mathematics courses, in particular, whose understanding is largely predicated on the students' ability to comprehend and master the previous material, have the unique potential to greatly benefit from a mastery-learning approach (Hsien-Tang, Liu, & Yuan, 2008).

In a computer-assisted, mastery-learning course design, students are allowed to redo homework assignments and retake randomly regenerated versions of quizzes and tests until reaching the aforementioned standard of concept mastery. With this approach, the high-stakes, anxiety-inducing model of assessment *of* learning is banished in favor of a much richer assessment *for* learning approach (Stiggins, 2007).

Problem Statement

Despite the viable accolades that were poised to stem from computer-based learning, it remained to be seen if mathematics students, particularly those at the developmental level of cognition and understanding, were capable of successfully receiving instruction in the form of self-paced, computer-based content delivery systems (Offer & Bos, 2009). While the allowance of assessment retakes theoretically solidifies higher raw test scores and cognitive levels of understanding, such a conjecture is fragilely placed upon the assumption that developmental math students are self-willed and meta-cognitively capable of operating and enduring a computer-based mathematics course. From cognitivist and constructivist perspectives, developmental math students could experience potential difficulties with independently constructing their own mathematical knowledge if left to their own devices (Witt & Schrodt, 2006).

Developmental students typically decide within the first six weeks of college whether they are sufficiently ready and academically capable of pursuing a college education (Speckler, 2011). As such, math – from the developmental all the way to the college level – has the power to significantly affect student completion, retention, and graduation rates. To this end, it remained to be seen whether or not developmental math students in technologically-redesigned courses could experience the same positive academic results as those documented among college algebra populations (Miller, 2010).

From a personal standpoint, the biggest impetus for conducting this research study was the degeneration of my developmental students' academic success since my school converted over to a technologically-redesigned manner of instruction, called the Emporium model. In evaluating the effectiveness of an instructionally-redesigned course, Twigg (2011) first suggested retrospectively comparing baseline data outcomes of traditional lecture methods of instruction with subsequent redesigned sections. Accordingly, in the five semesters since my school introduced computer-based learning, the pass rates in my developmental math sections dropped 21% while withdrawal rates rose 9% when compared against the last five semesters of lecture-based instruction. A brief chi-square analysis of the baseline data showed that both pass and withdrawal rates were significantly contingent upon instructional model ($\alpha < .01$). Tables 1 and 2 display the contingency table values of both the pass rates and completion rates when comparing baseline data between lecture-based and emporium models of instruction.

Table 1

Baseline Chi-Square Contingency Table of Completion Rates

Instructional Model	Finished Course	Unofficially Withdrew	Total
Lecture-Based	333 (322.6)	46 (56.4)	379
Computer-Based	142 (152.4)	37 (26.6)	179
Total	475	83	558

Note. Expected value in parenthesis. $\chi^2(1) = 6.99$ (*$\alpha < .01$)

Table 2

Baseline Chi-Squared Contingency Table of Pass Rates

Instructional Model	Pass	Fail	Total
Lecture-Based	217 (191.5)	162 (187.5)	379
Computer-Based	65 (90.5)	114 (88.5)	179
Total	282	276	558

Note. Expected value in parenthesis. $\chi^2(1) = 21.33$ ($^*\alpha < .005$)

Furthering the retrospective glance at my personal data, the effect size measures indicated that the odds for passing a developmental math course were 2.2 times higher in a lecture-based environment than in a technologically-redesigned model. Similarly, odds for withdrawing from the course were 1.9 times higher in computer-based models of instruction than in my traditional lecture environs.

While such data are simply a retelling of what has transpired in my personal classrooms, they are by no means steeped in validity. However, what the data managed to do was present a compelling argument for the need to research the academic and affective outcomes of computer-based learning on developmental math students. A research study involving concurrent samples of students in parallel course sections was needed to enhance the literature concerning the effects of an emporium-model redesign on developmental math students. Intended as an asset, did computer-based instruction live up to its pedagogical claims or did it actually hinder developmental math students' academic success?

Purpose Statement

While instructional redesign possesses certain fiscal and academic advantages, the question remained; could a full-scale adoption of instructional technology significantly improve student learning outcomes over traditional methods of instruction? As such, the purpose of this quantitative study was to determine whether technologically-based instruction improved student learning outcomes in developmental mathematics. Specifically, the research attempted to determine, through a quasi-experimental research design, whether students receiving instruction via technological redesign achieved significantly higher course completion rates, course pass rates, and semester-to-semester retention rates compared to students in the same developmental mathematics course who received instruction per traditional lecture methods.

Considering the at-risk population of developmental students, the study also aimed to investigate which affective factors, namely mathematics anxiety and locus of control, were bolstered through the mastery-learning and self-paced delivery of instruction that is synonymous with the emporium model of instructional redesign.

Identification of Variables

With instructional modality serving as the independent variable, the two populations of interest (e.g. "traditional lecture learners" versus "technological emporium learners") are ambiguously defined and need further clarification. For the intent of this study, a student who was taught in a "traditional lecture" sense received instruction through in-class, teacher-led lectures, learning activities, and lesson plans. By no means, however, was the “traditional lecture” meant to serve as an antiquated model of teaching, as instructors in the control group supplemented their daily lectures by assigning computer-assisted homework.

In contrast, students who received instruction via the emporium course redesign operated at an individualized, self-paced level, with learning stemming primarily from computerized tutoring software, supplemented at times with face-to-face personalized interactions with faculty members and peer tutors (NCAT, 2011). Specifically, emporium redesign boasts the following descriptive program features:

> It is heavily dependent on instructional software, including interactive tutorials, computational exercises, electronic hyper-textbooks, practice exercises, solutions to frequently asked questions, and online quizzes. Modularized online tutorials present course content with links to a variety of additional learning tools: streaming-video lectures, lecture notes, and exercises. Navigation is interactive; students can choose to see additional explanations and examples along the way. Online weekly practice quizzes replace weekly homework. A server-based testing system generates large databases of questions, and grading and record-keeping are automatic. (Twigg, 2011, para. 10)

In researching the dependent variables associated with student academic outcomes, it is important to note that, for the scope of the current study, academic outcomes were defined purely as transcript and enrollment measures. Under this framework, grades and attrition acted as two of the prominent dependent variables of student learning outcomes (Buzzetto-More & Ukoha, 2009). Course completion rates were determined by totaling the number of students actively participating up until the last day of the course. Students who stopped completing assignments and quit coming to class were awarded unofficial withdrawals (UWs) on their academic transcripts per university policy. Therefore, course completion rates were measured based on the number of students who received a letter grade out of the total number of students enrolled in the course (Zavarella & Ignash, 2009).

At the particular institutions where the study took place, passing letter grades of C (or C- in some instances) or higher are awarded to students who score an overall average of 70% or better. Pass rates, therefore, were determined by the number of students who made a C (or C- in some instances) or better out of the total number of students enrolled in the course. The third learning outcome measured, semester-to-semester retention rates, was determined by the number of students who enrolled in classes during the subsequent semester out of the total number of students who were enrolled the previous semester (Scott, Tolson, & Tse-Yang, 2009).

The affective dependent variables of mathematics anxiety/apprehension and locus of control are operationally defined in accordance with their respective scaled instruments. Student anxiety levels, defined as a psychological pathology interfering with one's ability to address mathematical issues (Rameau & Louime, 2007), were measured using the Mathematics Anxiety-Apprehension Survey (Ikegulu, 1998), while attributed feelings of control were assessed using Rotter's (1966) Internal-External Locus of Control Scale, with locus referring to the "place" – either internal or external - in which accountability is attributed (Weiner, 2003).

Significance of the Study

It was anticipated that the results of this study would have an influential effect on future teaching and instructional methods. In an increasingly technological age, teachers need to feel confident that computer-assisted instruction will not only provide a welcome diversion from lecture-dependent classrooms, but that instructional technology will also provide a legitimate means toward improving student learning (Bennett, 2001).

The significance of this study will also be felt in mathematics classrooms and other disciplines that are typically hierarchical in nature. The ill-conceived practice of herding students from unit to unit, regardless of their ability to fully grasp the prerequisite information, has been a debilitating tradition for both students and teachers for far too long (Block, 1979; Bloom, 1968). While colleges and universities have conventionally demanded that students learn course material in a predetermined length of time, typically denoted as a semester, the results of this study have far-reaching implications on those students who would have otherwise fared well in developmental education courses had they simply been granted an extra week or two to synthesize and fully comprehend the course curriculum (Stiggins, 2007).

The affective results of this study are of particular interest to the research and educational community. By shifting the responsibility of instruction from the teacher to the student, it was expected that computer-assisted learning would have a profound effect on redirecting students' locus of control. Under a technologically-enhanced emporium model of instruction, students are no longer subject to "mean" teachers who grade too harshly, "easy" teachers with laissez-faire attitudes, anxiety-inducing time constraints on tests, or any other undue burden that is outside of students' direct control. By shaping and grooming students' internal locus of control, it was anticipated that students would, in turn, become more excited about their educational endeavors, return to school with greater frequency, and feel better about the quality of their education, confident in their newfound ability to master the required curriculum (Abu-Hilal, 2002; Rotter, 1966).

Research Questions

While the primary purpose of this study was to investigate the academic effects of redesigning large enrollment, lecture-style, developmental math courses into self-paced, computer-assisted learning environments, the study allowed for a much-needed glimpse into the affective results of computer-dependent instruction, as well. According to the National Center of Academic Transformation (2011), the hypothesized benefits of a self-directed, technologically-enhanced model of instruction were linked to its ability to abolish feelings of testing anxiety that oftentimes befall students who have a storied history of struggling with mathematics, while concomitantly augmenting students' sense of personal autonomy and educational satisfaction. Therefore, the research investigated both the academic effects of technological course redesign in conjunction with its affective responses to mathematics anxiety and internal locus of control through the following overarching questions:

1. Are developmental math students more likely to complete and pass their course in a mastery-learning, computer-based environment, compared to those students receiving instruction in a traditional teacher-led classroom?

2. Are developmental math students more likely to return to school the following semester after participating in a mastery-learning, computer-based environment, compared to those students receiving instruction in a traditional teacher-led classroom?

3. Are developmental math students more likely to report fewer sensations of mathematics anxiety and a heightened locus of control after participating in a mastery-learning, computer-based environment, that are not evidenced among those students receiving instruction in a traditional teacher-led classroom?

These guiding research questions are posed in the form of the following hypotheses:

Null Hypotheses

H_o1: Courses taught by way of a computer-assisted instructional redesign will not achieve significantly different completion rates than those taught by traditional methods of instruction, as evidenced by unofficial withdrawal (UW) and withdrawal (W) rates.

H_o2: Courses taught by way of a computer-assisted instructional redesign will not achieve significantly different pass rates than those taught by traditional methods of instruction, as evidenced by the proportion of letter grades issued as a C (or C- in some courses) or better.

H_o3: Courses taught by way of a computer-assisted instructional redesign will not achieve significantly different semester-to-semester retention rates than those taught by traditional methods of instruction, as evidenced by confirmatory enrollment the following semester.

H_o4: Students taught by way of computer-assisted instructional redesign or traditional methods will not report significantly different mathematics apprehension and anxiety levels at the end of the semester than were initially reported at the beginning of the course, as evidenced by pre-post scores on the Mathematics Anxiety-Apprehension Survey.

H_o5: Students receiving instruction by way of computer-assisted instructional redesign or traditional methods will not report significantly different levels of control at the end of the semester than were initially reported at the beginning of the course, as evidenced by pre-post scores on Rotter's Internal-External Locus of Control Scale.

Definitions

1. *Computer-assisted instruction (CAI):* Any number of technological tutorial programs that supplements traditional teacher-directed instruction through the equitable use of homework sets, multimedia, and instantaneous assessment results (Spradlin, 2009).
2. *Course redesign (Instructional redesign):* Is the process of re-conceiving entire courses, rather than individual sections, to achieve better learning outcomes at a lower cost through the use of instructional technology (Twigg, 2011). Course redesign is not simply putting courses online; rather it is about rethinking the manner in which instruction is delivered to large-enrollment courses, in light of the possibilities that technology offers.
3. *Developmental education (mathematics):* Courses and programs designed to help underprepared students succeed in college-level courses (Boylan & Bonham, 2007).

4. *Emporium model:* Eliminates most class meetings and replaces them with a centralized learning center/computer lab that features online materials and on-demand personalized assistance from trained peer tutors and developmental math faculty (NCAT, 2011).
5. *Locus of control:* Refers to the place – either internal or external – to which individuals attribute their successes and failures. Luck and task difficulty are commonly attributed to things outside of one's control, while ability and effort are characterized as internal attributes (Weiner, 2003).
6. *Mastery learning:* Instructional model of providing corrective feedback and additional time for students to correct errors until a cycle of teaching, testing, re-teaching, and retesting is established (Bloom, 1968).
7. *Math anxiety:* The functional aspect of anxiety which includes negative thoughts and beliefs about one's ability to deal with mathematical tasks and procedures. The cognitive trademark of math anxiety is its ability to preoccupy the mind to the extent of reducing one's working capacity (Shields, 2007).
8. *Traditional instruction:* Regularly scheduled, face-to-face instruction delivered by an instructor, primarily through lecture, but not limited to additional pedagogical techniques such as collaborative learning and whole-class discussion (Bain, 2004).

Research Summary

A quasi-experimental research design was used to investigate the technological course redesign phenomenon. With the National Center for Academic Transformation (NCAT) still in its infancy, and fewer than 100 collegiate institutions adopting some form of technological course redesign (NCAT, 2011), exploratory research using a quasi-experimental design was well warranted. The impracticality and unethical practice of randomly selecting students and forcing them to register for either a lecture-based or emporium course section made a quasi-experimental approach much more realistic than a true experimental design.

Through a quasi-experimental design study, the research sought to identify differences between the non-manipulated independent variable (instructional modality) and the dependent variables (academic outcomes and affective measures). Emporium-model completion rates, pass rates, and semester-to-semester retention rates were compared against a population of students who received instruction via traditional teacher-led methods at a comparable institution, while student anxiety levels and locus of control within-group differences were determined from scores on pre-post surveys.

CHAPTER TWO: LITERATURE REVIEW

As more and more students are placed into perpetually high-risk courses such as developmental mathematics, valuable resources and funds are oftentimes diverted to assist students in improving their learning outcomes. In lean economic times, university administrators, as well as state legislators, culpably point fingers at developmental education courses for chewing up state monies by duplicating the same instructional material covered in the secondary school curriculum (Bahr, 2008). In response to the current plight of large-enrollment general and developmental education courses, the goal of the National Center for Academic Transformation (2011) is to redesign entire courses (rather than just individual classes or sections) to achieve better learning outcomes at a lower cost by taking advantage of the capabilities of information technology. Although the financial implications of technological course redesign certainly deserve merit, they should not overshadow technology's educational impetus to advance, challenge, and enhance the overall student educational experience.

Introduction

With over thirty years of formal recognition within the educational community, developmental education has sprung forth from its remediation roots to establish a bastion of scholars and instructors devoted to helping underprepared college students succeed at the post-secondary level (Boylan & Bonham, 2007). According to the National Center for Education Statistics (2003), 99% of community colleges and about 70% of universities offer developmental courses in reading, writing, and mathematics. Speckler (2011) estimated that up to 80 percent of incoming college freshmen place into developmental math courses.

With these statistics, higher education officials are growing cognizant of the idea that remediation can no longer be labeled with the same second-class stigmas as in years past.

Defending the need for developmental education at the post-secondary level, Bahr (2008) reiterated that it is certainly worth the cost to educate students over again by teaching them the same content that was paid for in high school. Gathering data from over 100 community colleges and 85,000 students, Bahr's regression analysis showed that the college algebra results of former developmental students are comparable with students entering college without any need for remedial assistance. Therefore, Bahr concluded that, as a major tenant in the community of higher education, any failures or shortcomings in developmental education cannot be covertly swept under the proverbial rug; for developmental education is here to stay.

At the heart of developmental education is a commitment toward helping underprepared students prepare, prepared students advance, and advanced students excel (Boylan & Bonham, 2007). In a report on behalf of the National Center for Developmental Education, Boylan, Bonham, and White (1999) expanded upon a "seven-category typology" for assessing the broad spectrum of underprepared, prepared, and advanced students in need of developmental services. While developmental courses are geared toward the acquisition of academic survival skills, they are by no means reserved for the intellectually-challenged. In essence, Boylan et al. assessed the following characteristics that lead to students being placed into developmental courses:

The poor chooser—those students who have made poor academic decisions throughout their formative years that have adversely affected their academic future. These students idled away much of their high school education by merely putting in the requisite seat time in order to graduate. *The adult student*—those "non-traditional students" over age twenty-five who have been out of school for several years. Adult students must juggle the responsibilities and demands of a full plate outside of school while adjusting to a life of academic study at the same time. *The student with a disability*—those who suffer from physical or learning disabilities that prevent them from performing as well as non-disabled students in academic pursuits. *The ignored*—those with physical, psychological, or other learning problems that have gone undiagnosed or consistently ignored in prior schooling. *The limited-English-proficiency student*—those whose native language is not English and, as a consequence, have limited English language and verbal skills to meet the demands of college-level courses. *The user*—those who attend college simply to hang out and attain the benefits associated with college life. They often have no clear academic goals, objectives, or purposes. *The extreme case*—those with severe emotional, psychological, or social problems that have prevented them from being successful in academic situations in the past, and will continue to haunt them as they move forward (Boylan et al., 1999).

In becoming acquainted with the various personalities, backgrounds, skills, and limitations that developmental students bring into the classroom, it becomes easier to deduce that perhaps the one-size-fits-all lecture-style format, consistently found among college educators, may actually be contributing to the abysmal success rates noted earlier. As such, the argument in behalf of emporium-based instruction grows by volumes as a result of technology's ability to tailor customized learning experiences to the individual learner.

This individualized learning experience is what Boylan and Bonham (2007) referred to when providing their own definition of developmental education. In sum, they contested that the renewed emphasis in favor of the word "developmental" as opposed to "remedial" is in the ideal that developmental education signifies the broad range of courses and services organized in an effort to retain students until successful completion of their collegiate goals, delivered according to the principles and theories of adult *development* and learning. Therefore, if developmental education is to become synonymous with the proper implementation of adult development and learning - and in order for computerized instruction to prove effective - it must be grounded in appropriate theories of learning and development.

Theoretical Framework

Instead of pulling from a hodgepodge of adult education, disability, multicultural, first-generational, and learning style theories, Kinney (2001b) argued for a unifying, established theory, specifically built for instructing developmental education students. As such, Kinney introduced a standard "developmental theory" based on the construct of self-regulation: defined as self-generated thoughts, feelings, and actions that relate to the attainment of one's educational goals. From an objectivist worldview, the self-regulation theories of mastery learning and assessment *for* learning spearhead the impetus behind educational technologies. The educational philosophies behind objectivism rely on the presupposition that one objective reality exists, and that students must be actively engaged within the subject matter in order to fully learn the material (Carson, 2005). When prior knowledge conflicts with newly acquired knowledge, learners simply update their knowledge bases to accommodate the objective reality that continually unfolds upon receipt of further light and knowledge.

Mastery Learning

Once a prevalent pedagogical theory nearly a half-century ago, mastery learning emerged as one of the era's more appealing educational practices due to its ability to increase student competence as well as confidence. As Bloom (1968) embarked on a theory toward mastery learning, he discovered that teachers who displayed the least variation in their instruction produced students with the widest variation of comprehension. This inverse relationship between teaching and learning caused Bloom to seek out an instructional pedagogy that would bridge the transfer gap between curriculum and instruction. Powered by the belief that all students are capable of learning for mastery, Bloom found that students could reach a high criterion of learning if instructional methods and time were better varied to match students' learning needs.

The rationale behind a mastery learning approach is that students learn best when they participate in a structured, systematic program of learning that enables them to progress in small, sequenced steps (Parkay, Hass, & Anctil, 2010). In terms of methodology, these steps generally include the taxing motions of providing corrective feedback and allowing additional time to correct errors until a cycle of teaching, testing, re-teaching, and retesting is established. As such, Hsien-Tang, Liu, and Yuan (2008) proclaimed that the most influential effects of mastery learning are found in remedial education.

In a study of over 1000 students who had been instructed according to Bloom's model of mastery learning, Geeslin (1984) found that students, from first grade to high school, overwhelmingly responded in a positive manner in confirmation of mastery learning. Unfortunately, mastery-learning activities soon proved to be cumbersome and time-consuming for both teachers and students, and were ultimately replaced with a standardized curriculum that emphasized breadth over depth (Hsien-Tang et al., 2008).

Just when the tedious practice of mastery learning appeared to be out of favor among educators, recent advents in educational technologies have once again renewed the fervor in favor of mastery learning. Notably, the principle attraction to computer-based instruction is in its ability to teach, test, grade, re-teach, re-test, and grade again, thereby invoking concept mastery. Consequently, researchers such as Guskey (2007) have begun resurrecting Bloom's commitments toward "teaching methods" and "time" in light of computer-based models of instruction. In revisiting Bloom's fundamental premises, Guskey found that the benefits of mastery learning are not all cognitive. The more time that students are allowed to digest and apply information before being herded through the next set of curriculum objectives, the more that students will improve on a wide variety of affective measures such as confidence in learning, school attendance rates, class involvement, and attitudes toward learning.

In an emporium-model course redesign environment, as students move about the course at their own pace, they are restricted from advancing in the curriculum until they have successfully mastered the previous unit's material at a predetermined ability level, usually set between 70 and 80% (Hagerty & Smith, 2005). Mathematics courses, in particular, whose understanding is largely predicated on the students' ability to comprehend and master previous material, have the unique potential to benefit from a mastery-learning approach. In a computer-based emporium model of instruction, students are allowed to redo homework assignments and retake randomly regenerated versions of quizzes and tests until reaching the aforementioned standard of concept mastery (Hoon, Chong, & Ngah, 2010).

Diversified Learning

In conjunction with mastery learning, computer-assisted learning software also lends itself well to reducing math anxiety with its extensive incorporation of multimedia. Courses taught through instructional redesign are no longer limited to lectures as the primary means of instruction. Instead, through the equitable use of video, audio, animation, textual, and interactive examples, multimedia offers the diversified ability to reach individual students by meeting their personal learning-style needs. In a sense, students are able to customize their lesson plans in ways that appeal to their learning styles and "speak" to them (Stiggins, 2007).

Comprehensive multimedia studies have found that consistent use of multimedia in the mathematics classroom significantly reduces numerical- and test-related anxieties in students.

As anxiety-inducing behaviors are eliminated, student self-confidence correspondingly increases (Taylor & Galligan, 2006). To this end, researchers emphatically proclaimed that computerized redesign strategies are just as important to the affective domain of student learning as they are to the cognitive side of instruction (Gupta, 2009; Stiggins, 2007; Smilkstein, 2003).

Instant Feedback

A third appeal of technological course redesign is its ability to deliver instantaneous and corrective feedback. Built on the premises of behaviorism (Skinner, 1960), students are able to work through the computer software's homework problems and respond to immediate stimuli in order to correct aversive and wrong perceptions, actions, and behaviors. In terms of mathematics instruction, Gupta (2009) discussed how instant feedback emboldens math students to increase participation and student engagement inside the classroom. Gupta also found that instant feedback has led to an increase of student activity outside of the classroom because penalties for wrong answers have been replaced by elements of constructive tutoring. In this manner, students are no longer afraid to try problems, thereby mitigating the frustration levels that typically accompany wrong answers as a result of the instant formative feedback.

Like Gupta (2009), Cotner, et al. (2008) also reported increased levels of student engagement when instant feedback technologies were employed, while also noting the importance of feedback in preparing for examinations. In accordance with the pedagogy of computer-assisted redesign, students are given the ability to evaluate their own personal strengths and weaknesses, and then asked to identify procedures for remediating those shortcomings. By employing a more formative, rather than summative, approach to assessment, technological course redesign gradually helps students construct their learning to a point where they are motivationally engaged, affectively confident, and cognitively competent to master their summative exams.

As director of the National Association of Developmental Education (NADE), Hunter Boylan (2005) compiled a list of research-based best practices for teaching developmental students. Chief among Boylan's priorities was a call to increase the amount of testing in developmental programs. Frequent testing gives developmental students the opportunity to practice their skills and receive recurrent feedback concerning their level of understanding. Accordingly, developmental students are more successful in courses in which opportunities are provided via regular assessment. To this end, a philosophical marriage between research-based best practices and computer-assisted instruction provides students with the valuable practice and learning opportunities that accompany the frequent-testing models of mastery learning.

Affective Outcomes of Mastery Learning

Indirectly linked to a mastery learning environment are the identifiable residual effects on math anxiety and locus of control. A syllogistic argument in favor of mastery learning presupposes that the more time students are allotted to work out their misunderstandings, the more ownership and confidence they feel with respect to their mathematical ability, resulting in fewer occurrences of mathematically-induced anxieties (Smith, 1998).

Math anxiety. Worry is the cognitive aspect of anxiety which includes negative thoughts and beliefs about one's ability to deal with a situation (Ormrod, 2004). The cognitive trademark of worry is its ability to preoccupy the mind to the extent of reducing one's working capacity (Shields, 2007). Math anxiety's psychological symptoms include nervousness, panic, edginess, and helplessness. Smilkstein (2003) readily defended the assertion that worry affects learning. She used brain research to establish her theory that worry produces chemicals that enter the brain and physiologically affect neural synapses and, consequently, the brain's ability to think. Applying knowledge of flight and fight hormones, Smilkstein contends that it is not uncommon for students with able memories and significant neural structures of learning to sit down for a test, only to have their brains go blank. "What has happened is that chemicals produced by anxiety (perhaps about not being able to succeed) have invaded their synaptic spaces and sabotaged their brains' ability to think and remember" (p. 86). The so-called fight response makes people focus, pay attention, and marshal their forces in a facilitative manner that enhances performance (Ormrod, 2004), whereas the flight response debilitates behavior, causing immobilization and an inability to think and remember.

Mental blocks can be frustrating for students who feel that the high-stakes nature of tests jeopardizes their ability to calmly demonstrate their true level of learning. By changing the classroom's assessment climate from an educational ultimatum to a mastery learning environment of trial and error, Smilkstein (2003) contended that mathematical apprehension and anxiety can be overcome.

A seemingly obvious cause of math-induced worry is poor performance. Significant associations are commonly found between low test scores and high math anxiety (Shields, 2007). Students who rely heavily on calculator usage to equate basic multiplication facts have poor control of their mathematical fears (Bull, 2009), while others choose career and technical education (CTE) pathways as a lifelong consequence of avoiding math classes. College-bound students with poor math attitudes freely admit that they choose college majors that require the least math, as it has been reported that 75% of Americans stop studying math before they have completed the educational requirements for their occupation (Scarpello, 2007). Similarly, students who have high levels of math anxiety may be less likely to pursue math courses or math-related careers. Therefore, "an indirect effect of mathematical anxiety is that of avoiding studies related to math" (Thilmany, 2009, p.11).

Teachers as causes of math anxiety. For years, conventional thinking supposed that people feared math because they were bad at it. However, a growing body of research shows that students are more likely to blame teacher attitudes and ineffective teaching strategies as the primary sources of their math anxiety. In Shields' (2007) study, she found that only 16 percent of participants attributed their lack of understanding to math anxiety, whereas 61 percent of surveyed participants, and eight out of ten interviewed, attributed their math anxiety to teachers.

When interviewees were asked what specifically caused their anxiety, they spoke of teachers who taught too fast, showed little or no enthusiasm for the subject, and subjected students to humiliating activities like working at the board. Furthermore, math teachers, in particular, are frequently guilty of talking about concepts, rather than talking through them; dancing around the edges of explanations, almost afraid to begin; and assuming that listeners have either already heard the story or would be bored at its telling (Bain, 2004).

Technology-centered solutions to math anxiety. On par with current trends within higher education, schools like Northwest Mississippi Community College have been acknowledged for their student-friendly solutions in coping with the emotional stress caused by test anxiety ("Calming Area," 2007). Students who are battling anxiety can seek refuge in the school's calming area – a place where students can meditate and clear their thoughts before they take their tests. However, as therapeutic as tranquility gardens or positive self-talk may be, Smith (1998) warned students that feelings are no substitute for knowledge. Reducing mathematical anxieties should not be the primary learning goal. Instead, students need to focus their attention on gaining mathematical knowledge.

Good feelings about math do not put procedural knowledge in one's head. As such, Smith (1998) advised students to organize a study plan that will breed success in mathematics - for success dissipates the residual trepidations of math anxiety. Walsh (2008) also found success to be the ultimate conqueror of math anxiety. While many of her students initially experienced mild anxiety from the outset of each test, they quickly discovered that their tensions relaxed upon correctly solving the first few problems. Students in Walsh's study consistently reported that their anxiety levels decreased and confidence levels increased as a result of focused mathematics practice.

The ability to cope with the pressures of high-stakes tests is essential in combating math anxiety because, for many students, the nature of their fears lies specifically with mathematics *test* anxiety as opposed to mathematics anxiety (Wong, 2009). Consequently, many students afflicted with math anxiety could be fundamentally rehabilitated if teachers were to adopt a school of thought that promoted assessment *for* learning, as opposed to assessment *of* learning (Stiggins, 2007). If students were able to use tests as a gauge of where their learning is with respect to where it needs to be, teachers could offer test re-takes until students achieve desired levels of proficiency. A philosophical shift toward assessment for learning could potentially end mathematics test anxiety as it is known today.

Locus of control. In addition to a possible eradication of math-related anxieties, a second perceived benefit in adopting a mastery learning model of instruction lies in the concomitant ownership and control that await students as they work, and subsequently rework, mathematical objectives until they are satisfied with their level of understanding (Twigg, 2011). In one of the foundational studies linking locus of control to computer-assisted instruction, Reglin (1987) found that students using computer-assisted software not only increased in mathematics achievement, but developed a more internal sense of attribution through its use.

Establishing the term "locus of control" into psychological and sociological domains, Rotter (1966) described locus of control as the extent to which individuals believe they can control their life events. Internal attribution stems from one's own abilities and actions (such as grades earned) and exhibit high achievement motivation; while external attribution posits that fate is determined by others, chance, and luck (grades given by capricious professors), manifested by lower academic performance levels.

In addition to locus, attribution theorists have identified two other dichotomous dimensions of accountability that collectively contribute to an individual's explanatory success and failure: stability and controllability. Whereas locus refers to the "place" – either internal or external - in which accountability is attributed, stability refers to the changing (stable versus unstable) view of circumstances; while controllability takes into account an individual's perception as to the relative controllable versus uncontrollable nature of factors (Ormrod, 2004). Four recurrent factors cited among attribution theorists include luck, ability, effort, and task difficulty (Siegel & Shaughnessy, 1996). A matrix identifying the four major attributes along each of the three dimensions can be seen in Table 3.

Table 3

Dimensional Matrix of Attribution Theory

Attribute	Three Dimensions of Attribution Theory		
	Locus	Stability	Controllability
Luck	external	unstable	uncontrollable
Ability	internal	stable	uncontrollable
Effort	internal	unstable	controllable
Task Difficulty	external	stable	uncontrollable

When applying attribution theory to the arena of education, students are most persistent when they attribute their successes to internally stable and dependable factors such as ability and their failures to unstable, yet controllable factors such as lack of effort (Weiner, 2003). Conversely, many students develop self-handicapping attributions that place "blame" on external and uncontrollable factors, toward a vortex of learned helplessness. Students who think they will fail a difficult test may be inclined to refrain from studying for that test. Their line of thinking typically takes more of a defensive stance rather than offensive production as shown in the following succession of student thoughts:

What if I study hard and then fail?...then I will know I do not have the same ability level as my classmates…since I am probably going to fail, I may as well not study because then I can blame my resolute failure on the fact that I did not study, and not on my stupidity...if I study hard and pass, that diminishes my natural talent and the subsequent glory attached to my success…and if I do not study and still pass, then people will know that I am a natural genius…therefore, the only true course of action is to avoid putting forth the effort, while instead, putting faith in the externally uncontrollable (Weiner, 2003).

This line of reasoning becomes counterproductive because the objective reality contends that the person who expends less effort is actually less likely to be productive, but a student wrapped up in a cycle of learned helplessness has come to believe the aforementioned thought experiment to be a win-win matchup against stable and uncontrollable factors such as mean teachers, hard tests, or poor results after previous attempts at studying.

Weiner (2003) warned that teachers may unintentionally be sending negative motivational cues via typically-germane student interactions. He stated that polite discussions where students are not criticized for failing menial tasks actually convey to the student that he or she has a low ability and is not expected to perform any better. Likewise, a caring gesture where the teacher provides unsolicited help often evokes beliefs by the student that he or she lacks ability and is in constant need of teacher assistance. As a result, Weiner suggested that punishing failure for easy tasks and not providing unsolicited help best motivate students because it communicates that the cause of failure was a transparent lack of effort, and not ability. This distinction is imperative because effort is controllable and can be changed, while ability is considered a stable ceiling-level attribute.

In terms of teacher feedback, the transitive property of logical argument would presuppose that since teachers are oftentimes culpable of dispensing signals that target ability, a computer-mediated response system would serve a much-needed purpose of reassuring students' ability-level while constructively honing in on effort and time spent on task. To this end, mastery-learning mathematics software such as MyMathLab and MathXL unwittingly complement the mission of attribution theory by rewarding students for ability and effort.

Investigating the learning behaviors of online developmental math students, Wadsworth, Husman, Duggan, and Pennington (2007) found that self-efficacy, motivation, concentration, information processing, and self-testing were all significant contributors to academic success, with internalized self-efficacy largely accounting for 42% of the variance in online achievement. Similarly, Chang (2005) found that students who were given explicit opportunities to apply self-regulatory strategies as part of their web-based coursework were significantly more likely to improve their focus toward intrinsically-motivated strategies for learning and self-efficacy. Throughout the course of the study, Chang observed students who became more confident, more challengeable, and more involved in the pure pursuit of learning after experiencing internally-based self-regulatory strategies as part of their online instruction. The true educational value of Chang's study, therefore, was in its manifestation that reflective self-regulatory activities, embedded within a computerized context, have the ability to encourage learners to refine their internal locus of control by taking a greater measure of responsibility in their own learning.

Whereas learned helplessness attributes success to external factors such as luck and failure on a lack of ability, mastery-learning software's instantaneous feedback promotes a culture of learning *from* failures rather than dismissing failures as a result of a host of external culprits (Stiggins, 2007). Surprisingly, few of the current arguments in favor of instructional technologies make connections between mastery learning and attribution theory's locus of control.

Biblical Integration

In deference to a biblical worldview, mastery learning and assessment for learning practices are steeped in the gospel principles of repentance, forgiveness, and self-mastery. The juxtaposition between traditional learning methods and mastery learning techniques illustrates the immense amount of grace deferred to students when assessed *for* learning rather than *of* their learning. While traditional methods of instruction limit students to one or two chances to achieve perfection, mastery learning relies on students to make mistakes so that they may fully profit by learning from their errors.

Similarly, the Lord mercifully extends His forgiving hand and encourages His children to learn from their mistakes: "For I will be merciful to their unrighteousness, and their sins and their iniquities will I remember no more" (Hebrews 8:12, King James Version). The great prophet of the Old Testament, Isaiah, frequently bore record of the Lord's forgiveness. "I, even I, am he that blotteth out thy transgressions for mine own sake, and will not remember thy sins" (Isaiah 43:25). Given the fact that computer-assisted models of mastery learning will only record the highest achieved scores, while "blotting out" all lower scores from the grade book, the parallels between gospel principles and mastery learning techniques run high.

Perhaps one of the most questionable elements in applying computer-assisted instruction to a population of developmental math students is the inordinate amount of self-discipline and time management required to be successful in an emporium-model experience. However, the scriptures speak clearly about the necessity of honing one's personal efficacy and discipline, for "he that hath no rule over his own spirit is like a city that is broken down, and without walls" (Proverbs 25:28). The need to temper one's carnal desires was indicative of the message conveyed by Paul to the Corinthians: "And every man that striveth for the mastery is temperate in all things" (1 Corinthians 9:25). Self-discipline is an undeniable facet of mastery learning that must be taken into consideration when implementing computer-assisted instruction into the arena of developmental math. While it remains to be seen whether or not developmental math students are capable of such self-restraint, the importance of cultivating discipline is paramount in any emporium-model redesign.

Review of the Literature

The body of literature concerning computer-assisted instruction is noticeably diversified and inconclusive. Firstly, the manner in which technological instruction is implemented in the classroom varies along a widespread continuum, ranging from assistive supplementation to a complete replacement of the traditional classroom model. While a conservative majority of the literature has detailed the topic of enhancing classroom lectures with the virtues of instructional technology, a few pioneering researchers have emerged over the past several years and have begun exploring the possibilities of redesigning the entire classroom experience in which technology and human interaction merge together into an educational hybrid. Considering the lecture-replacement scope of this current research study, it is vital to discern between the gradations of computer-assisted models before appropriate comparisons and applications can be inferred.

Secondly, although a broad range of computer-assisted studies populates educational research, the diversified portfolio of studies can agree on one commonality: the research concerning instructional technology is polarized. Seemingly equal numbers of studies hail computer-assisted instruction as they do assail its educational effects. In the following review of literature, an even-handed portrait of technological supplements and hybrids will be critiqued, uncovering the resultant duality of computer-assisted instruction.

Backed by a bona fide theoretical framework and reinforced by sound implementation strategies, the use of computer-assisted instruction in developmental math courses would appear to be a sure-fire success (Graves & Twigg, 2006; Pearson Education, 2009; Twigg, 2011). In the milieu of educational research, however, the reports surrounding technological instruction is a mixed bag of pontifications, projections, and proven results. While several authors have made claims based on observational patterns and anecdotal evidences (Bennett, 2001; Boggs et al., 2004; Hammerman & Goldberg, 2003; Kinney & Robertson, 2003), an extensive amount of empirically-tested research has shown computer-assisted instruction to be a significant contributor toward student achievement (Brothen & Wambach, 2000; Canfield, 2001; Cotton, 1991; Ford & Klicka, 1998).

Current Strategies for Implementing Computer-Assisted Instruction

As heretofore discussed, the heterogeneous nature of developmental students suggests that a traditional model of teaching and learning is in need of an overhaul. To propose that one instructional size fits all is to propose that failure is imminent for the seven different types of developmental students (Boylan et al., 1999). Directors and Programmers of developmental education should incorporate as much flexibility and as many different modes of instruction as possible to accommodate the needs of developmental learners (Kinney & Robertson, 2003).

In relative terms, the research on computer-assisted instruction is comparatively new in the field of developmental education. Before research studies began to surface on college campuses, the most extensive results were coming from cutting-edge or nationally-sponsored organizations. As part of the Northwest Regional Educational Laboratory's (NWREL) initiative to research school improvement projects, Cotton (1991) tabulated the effects of computer-assisted instruction for over two decades. Based on years of research results, one particular school improvement project that earned the endorsement of the NWREL was the implementation of computer-assisted instruction. Among the myriad of positive results, Cotton concluded that programs using computer-assisted instruction witnessed positive effects on student learning and attitudes.

The Educational Testing Service (ETS) followed up the NWERL's results with a nationwide study designed to investigate the relationships between educational technology and mathematics achievement (Wenglinsky, 1998). With results corralled from every corner of the country, along each cross-section of K-12 education, the ETS concluded that the findings implicated computers as neither the cure-all that proponents hyped them up to be, nor the fickle fad that lamenters speculated would become of educational technology. Though observations from Wenglinsky's study could not be generalized to the post-secondary level, the same ambiguous balance between teacher proximity and computer presence soon spilled over into the collegiate debates.

Supplementing lecture. For most developmental students, the didactic lecture was neither effective nor appealing the first time through the educational system, thereby rendering a second go-round nearly futile. In this regard, Trenholm (2006) argued that the unacceptability of 40-50% pass rates is ultimately compounded by the inefficiency of college professors to tap into the modalities and interests of the current generation of college freshmen. "Millennials," as they have come to be termed, have been characterized as heavy users of technology, and as such, should be presented with a variety of instructional formats that rely predominantly on the educational merits of technology. Only through technology are new models of developmental mathematics instruction made possible (Kinney & Robertson, 2003). To this end, many developmental educators began delving into the arena of computerized homework so that their students would be able to have access to immediate, one-on-one assistance when working through homework sets.

The Supplemental Model of technological instruction retains the basic structure of the traditional course while supplementing lectures and texts with technology-based, out-of-class activities. In terms of educational significance and practical implementation, where the benefits of whole-class instruction end, the boons of technological practice begin. Bennett (2001) surmised that direct education at the digital hands of a computer would equip each student with a private tutor throughout his or her educational career. Through frequent methods of assessment, the computer would become aware of any informational deficiencies and work privately with the student to remediate and correct any problems. According to Stiggins (2007), the technological tutor would not demand perfection, but would still insist on a certain level of mastery before presenting new tutorials, simulations, or animations, all while reviewing critical concepts in a cumulative fashion along the way.

The appeal of the technological tutor, as interpreted by Bennett (2001), is that it helps reduce many of the societal fears and stigmas of public humiliation and embarrassment that oftentimes plague developmental populations, especially those who fail to initially comprehend the material. Under an educational system directed by computerized tutorials, the “fear of trying” is eliminated as students are neither blamed nor teased for not knowing a particular answer. Individualized instruction would praise success while providing encouraging hints in times of failure.

While the history of computer-assisted learning has dabbled primarily in the monotony of skill and drill problem sets, Hammerman and Goldberg (2003) addressed technological strategies for reversing the negative attitudes towards computers in regards to remediation. They contended that presenting meaningful, not memorized, material needs to be considered when incorporating relevance into today’s personalized computer-assisted interactions. Further, Ross and Bruce (2009) envisioned instructional technology platforms that could effectively streamline scaffolding and sequencing of hierarchical math topics.

Whether the e-learning platforms are Blackboard, MathXL, MyMathLab, ALEKS, CognitiveTutor, Thinkwell, NetTutor, or any other among a host of computer-assisted software, the quest for mastery learning of mathematical content is catalyzed by the implementation of personalized, interactive computer tutorials (Boggs, Shore, & Shore, 2004). Dubbed as Interactive Learning Systems (Kennedy, Ellis, Oien, & Benoit, 2007), these educational technologies can be paused, rewound, and replayed over and over again until the concept is internalized, unlike a traditional lecture.

Reporting on data of 55 colleges and universities that implemented either the MathXL or MyMathLab product line as a homework supplement to in-class instruction, Speckler (2011) found that more than 80% of surveyed students reported satisfaction with the software. Students cited the ease of use, helpful learning aides, immediate feedback, motivational cues, increased practice, accommodating learning styles, and the work-from-anywhere convenience as exceptional plusses of computer-assisted course supplements.

Student feedback was similarly favorable in Jacobson's (2006) study of pre-algebra courses in which homework was delivered through a web-based tutorial system. Students enjoyed the instant feedback of knowing whether they were right or wrong, along with the "help" and "show me an example" features of the tutorials. Surprisingly, positive student reviews did not translate into increased gain scores on course examinations when compared to a control group. In a similar study of developmental math courses, Spradlin (2009) also failed to witness a significance difference in academic achievement between courses utilizing computer-aided instruction and those without.

While computerized homework and test management systems are presented as a means for meeting the instructional needs of individual learners, Buzzetto-More and Ukoha (2009) added that the benefits of automated assessment are graciously welcomed by assessment-weary faculty members. Though developmental faculty members were grateful to retire their red pens and answer keys, student responses to the online conversion of assignments, quizzes, and e-book were marked by high levels of neutrality. Students indicated a sense of value in the technology as a learning system and tool; however, most students responded that they were not satisfied with the overall design of the course. Despite neutral reviews, student performance was markedly better when compared against previous years, as evidenced by lower withdrawal rates and higher pass rates.

The positive reviews in regards to computerized homework and assessment assistance are of no surprise to educational software developers. Pearson Education, Inc. (2011), publisher of several prominent computerized tutorial software programs such as MyMathLab and MathXL, listed a 14-page compendium of colleges and universities that have testified of the successes brought about by the implementation of computer-assisted programs in their developmental math courses. Increased graduation rates, pass rates, completion rates, success in subsequent courses, participation, and final exam grade are each lauded in testimonial-fashion. As a result, more developmental students are experiencing success in math because more developmental students are doing the math. The research has shown that computer-assisted homework is most effective when built upon interactive classroom discussions that are personalized for the individual learner. By supplementing teacher instruction with a variety of instructional methods such as instantaneous feedback, video animations, and positive reinforcement, students are able to fulfill

Bloom's (1968) theory of mastery learning in route to enjoying more successful experiences in developmental math courses once wrought with failure.

Replacing lecture. In light of the documented successes of computer-assisted mathematics tutorials, the NCAT (2011) began pioneering use of the term "course redesign" to effectuate a paradigm shift toward using technology where technology makes sense (Graves & Twigg, 2006). While most institutions know how to put courses online, the NCAT helps schools leverage their technological investments to show measureable increases in learning while reducing the cost to the institution. As such, course redesign does not attempt to replace proven pedagogies, but build on them by implementing technologies that promote active learning for mastery, elicit prompt feedback, and encourage time on task in large-enrollment courses that would be impossible otherwise, without the use of technology.

The manner in which the traditional teacher-led lecture is replaced is carried out by any one of the following five models: Replacement (Hybrid), Linked Workshop, Fully Online, Emporium (Lab), and Buffet (NCAT, 2011).

Replacement (Hybrid) model. This model of course redesign reduces the number of in-class meetings by exchanging lecture time with out-of-class, online, interactive learning activities. The remaining in-class meetings are altered to meet the needs of individual struggles that students may require help resolving.

Linked workshop model. Developmental instruction is provided by linking just-in-time supplemental workshops for core college-level courses.

Fully online model. The fully online model is currently the most utilized delivery medium of technological instruction. All in-class meetings are eliminated and moved online through the use of Web-based multimedia resources. Assessments are automatically evaluated with guided feedback.

Emporium (lab) model. The Emporium model is the model that was investigated in this research study. In place of class meeting times, students are instructed to attend a learning resource center (tutoring lab) where peer tutors and faculty members offer on-demand personalized assistance. Lab attendance can be mandatory or voluntary based on student motivation and experience levels. For the developmental students in this current research study, two hours of weekly lab attendance was required as part of their grade. An additional hour was required each week for class time in which students reconvened with their instructor and discussed weekly goals, past achievements, and current struggles.

Buffet model. The learning experience in the buffet model is customized for each student depending on student preferences, commitments, academic history, or class schedule. A combination of the above models may be offered, leaving the choice of instructional model in the hands of the individual student (Pearson Education, 2009).

The underlying principle for mathematical success in the technological redesign model is clear: students learn math by doing math (Twigg, 2011). Dixielee Blackinton, a math education professor who has witnessed the emergence of computer-assisted instruction at her four-year university, echoed this philosophy by proclaiming that students learn math by doing math, not by listening to someone talk about doing math (personal communication, April 4, 2011).

The use of MyMathLab in an NCAT redesign successfully creates proven characteristics for student achievement such as active learning, student engagement, individualized assistance, round-the-clock access to online learning materials, consistent practice and reinforcement, adaptability to differences in learning styles, and immediate feedback from automated grading of homework, quizzes, and exams (Pearson Education, 2009). MyMathLab ensures that students spend the bulk of their course time actually doing math problems. In lieu of biding time on concepts that they have already mastered, students are liberated to spend a majority of their time on hard-to-understand objectives such as logarithms, fractions, or story problems. In sum, interactive computer software, combined with personalized instruction from a caring educator, comprise the key elements of student success (Twigg, 2011).

From a pedagogical standpoint, the emporium model follows the trail of positive literature reviews of computer-assisted instruction and combines it with one-on-one on-demand assistance from trained peer tutors and knowledgeable faculty members. With all assessments becoming automated - and learning taking place from software tutorials and e-texts - faculty members in an emporium model exchange grading time and lecture preparation time for personalized instructional opportunities in the lab (Twigg, 2011). By keeping teachers involved in the learning dynamic, students are able to procure first-hand explanations and one-on-one counseling that would have been otherwise impossible in a large-enrollment developmental course: "One key part of the effectiveness of technology in the classroom is student-teacher interaction. This human interaction must continue as the main form of formal instruction with technology acting as a conduit for this to take place efficiently" (Robinson, 1995, p. 2). The positive impact of one-on-one on-demand assistance extends well into the affective domain as well, with increases in attitudes towards school, self-concept, and academic self-efficacy attributed to peer tutoring (Robinson, Schofield, & Steers-Wentzell, 2005).

The work of Hagerty and Smith (2005) idyllically illustrated the principles of engagement, confidence, and competence that are espoused by proponents of technological redesign. In their study, Hagerty and Smith found that college algebra students using an online learning system academically outperformed their institutional counterparts who received instruction via traditional lecture methods. What made the results of Hagerty and Smith even more argumentatively stable was that they were derived from a true experimental design in which the experimental group was randomly selected and compared against a similar sample of randomly selected control students.

A comparable study conducted by Hoon et al. (2010) corroborated the work of Hagerty and Smith (2005) in regards to computer-aided academic performance in a college algebra class. Specifically, in learning the concept of matrices, Hoon et al. found that students who used interactive multimedia software to achieve a predetermined level of mastery made significantly higher marks on a standardized assessment than students who received instruction via more traditional methods. Further, Butler and Zerr (2005), along with Witkowsky (2008), each found that college mathematics students responded well to mastery-learning strategies and computer-moderated instant feedback through the demonstration of both cognitive and affective gains.

Branding the slogan, “Do the Math,” Twigg (2011) contended that instructional redesign is the silver bullet that higher education has been searching for. As head of the NCAT, Twigg has had a direct hand in NCAT-redesign partnerships for the past decade. Over her years of redesign implementation, she has seen completion rates increase by 51% in developmental math, while reducing costs by 30% on average. As such, course redesign benefits are not merely limited to student success, but garner particular attention when cost savings are introduced into the equation. As a result, an institution’s cost per student can be lowered by freeing faculty from tedious tasks, such as grading, by allowing them to “teach” upwards of 11-12 course sections in addition to providing 8-10 hours of assistance in the lab (Pearson Education, 2009).

Consequently, the need for adjuncts and graduate assistants is eliminated or greatly reduced (Twigg, 2011).

The infancy of Instructional Redesign. Despite the firm pedagogical foundations that support and validate a conversion to computer-assisted instructional models, the idea of whole-scale course redesign has yet to become mainstreamed into the American system of higher education (NCAT, 2011), while international attention lunges ahead, toward the progression of instructional technology. In a meta-analysis of 30 Turkish-based studies, Yesilyurt (2010) found that computer-assisted instruction demonstrated a level of superiority that could not be matched by traditional methods of teaching. In addition to Turkey, similar findings involving technology and higher education can be linked to Australia (Gupta, 2009), Malaysia (Hoon, et al., 2010), and England (Kodippili & Senaratne, 2008), with trace amounts of research originating from American literature. Even comparative studies of Cognitive Tutor software in Hawaii (Cabalo, Jaciw, & Vu, 2007) yielded samples of community college students from a variety of ethnically diverse backgrounds, similar to those found on the world stage.

While much of the landscape in American higher education has been hesitant to employ full-scale, technologically-enhanced redesigns of mathematics courses, the University of Alabama has shown few signs of reluctance in adopting the emporium model approach for instructing its lower level mathematics courses (Witkowsky, 2008). Within a period of eight years, Witkowsky reported that pass rates finally surpassed the 50% mark before consistently settling in between 60% and 70% success rates. Similar success stories have since followed, with institutions such as the University of Idaho and Virginia Tech University spotlighted as evidences of instructional redesign’s success (Twigg, 2011).

Perhaps the most promising literature regarding developmental mathematics and the emporium model comes out of Cleveland State Community College (CSCC). Described as a balance of high tech and high touch, the emporium model at CSCC employs a division of responsibilities that allows computers to do what they do best and teachers to do what they do best (Stern, 2012). Since implementation, pass rates at Cleveland State went from 54 percent to 74 percent, while the number of students passing subsequent college-level math courses rose 62 percent. Stern went on to report that of the remaining 26 percent of students who do not pass in one semester, most of them pick up right where they left off and finish the following semester.

Built upon the principle cornerstone of internal localization of control, CSCC students are now the primary catalysts for their own success. In an emporium model, students are the ones doing the math; they are engaged in doing the math, and not passively watching a pontificating teacher. In concert with students' increased time on task is the luxury of allowing students to work at their own pace. In addition to the gamut of learning style options that the emporium model offers, Stern (2012) also cited mandatory mastery as a benefit that helps students become better prepared for sequential concepts. While the successes at CSCC offer promising results, they are not without their share of formidable critics.

Skepticism and Resistance

According to Smith and Ferguson (2004), some of the earliest resistance toward computer-based instruction grew out of frustrations over the inability to communicate on the computer using proper math symbols and notation. Exponents, long division bars, radicals, coordinate planes, and even fractions were difficult to compose using basic keyboard approaches. Refined toolbars soon evolved, causing computer-assisted instruction to revert back to arithmetic skill and drill exercises. As the acceleration of technology soon brought about a host of easy-to-facilitate math notation learning systems such as NetTutor and Whiteboard, critics of computer-assisted learning quickly turned to other avenues of skepticism to discredit the use of educational technologies.

The most common argument against computer-assisted instruction stem from social learning advocates who claim that computerized teaching and learning lacks the necessary human components of expert modeling, interaction, and question resolution. An exploration into the effectiveness of computer-assisted instruction at the community college level indicated that the lack of human explanation and concomitant absence of mathematical think-aloud processes brought about the demise of students enrolled in a Fundamentals of Mathematics course (Ford & Klicka, 1998). Traditional teacher-led instruction in a Basic Algebra course at the same school also produced significant results, outshining computer-assistance sections in both pass and retention rates. Although Ford and Klicka reported significantly higher final exam scores for the computer-assisted sections, the authors recognized that poor implementation strategies and a lack of universal “buy in” from the faculty prevented the computer-assisted sections from gaining any traction against the stalwart traditionalists of routine.

At a gathering of educators concerned about the inevitable wave of technology, Young (1998) raised concerns about the pedagogical value, impact on professorial life, and the money-driven infatuation of implementing instructional redesign concepts. Independent concerns were also raised in regards to what students truly desire when it comes to instructional delivery. Caruso and Salaway (2007) reported that while most students said they want to see technology incorporated in their courses, the majority reported that they like to see it used to a moderate degree (59.3%) with 20.4% saying they favor extensive use, 15% preferring limited use.

Ultimately, Caruso and Salaway (2007) concluded that students prefer courses that balance informational technology with a traditional classroom experience that involves strong teacher interaction and face-to-face communication. Illustrative of these student needs was a research study conducted by Stillson and Alsup (2003) in which the computerized-learning system, ALEKS, produced mixed results regarding student perception and academic success. Throughout the study, Stillson and Alsup expressed concern for the students who refused to take advantage of the ALEKS system, due to poor motivation, lack of study skills, or an aversive intimidation of technology. In the end, Stillson and Alsup concluded that the ALEKS learning system caused more confusion and frustration in a course that was inherently difficult to begin with. As a result, many struggling students failed the course or readily dropped it from their schedules. Interestingly, despite the high failure rate for the course, participants reported that they felt like they learned more using the ALEKS system than had they gone without.

In response to the negative outcomes, Stillson and Alsup (2003) recommended that only students with a discernible aptitude for self-directed learning be encouraged to take the ALEKS-enhanced course. As for the majority of developmental students who do not exhibit such self-directed and motivating behaviors, the authors acknowledged that difficult math concepts require the explanation, patience, and direction of an expert instructor. According to Stillson and Alsup, working in groups and asking questions in class still takes precedence in an optimal learning environment. Though not entirely discounting the ALEKS learning system, the researchers agreed that it would be in the best interest of teachers and students alike to supplement traditional classroom instruction with educational technology, rather than attempt to replace it.

While much of the skeptical literature questions the effectiveness of course redesign with relative diplomacy, Zavarella and Ignash (2009) remained unabashedly critical of computerized instruction as a result of their findings concerning developmental math students. In their study, Zavarella and Ignash noted significantly higher withdrawal rates in both the hybrid course redesign and online course formats than in sections taught in a traditional lecture-based model, with students twice as likely to withdraw if they were enrolled in a technologically-based course section. Moreover, Zavarella and Ignash proceeded to discount the effects that computerized instruction has on learning styles, detecting no relationship between learning styles and completion rates.

In exploring the associated effects of teacher presence and technology usage on student achievement, Witt and Schrodt (2006) furthered the arguments against course redesign in finding that courses which abided by the extremes of either of the two variables frequently alienated their students in ways that produced negative academic effects. The curvilinear results of their research demonstrated that classrooms adhering to moderate levels of teacher and technological presence yield significantly higher academic outcomes. In terms of whole-scale course redesign, the veritable absence of an instructor, coupled with its technological demand, has the potential to overwhelm its average student consumer.

Though Witt and Schrodt (2006) advocated moderation in the usage of technology, Bos (2009) tempered the argument by stating that the inherent problem with instructional redesign is not in its use of technology, but in how it is used. Citing an undue emphasis on the lowest levels of cognition, Bos bemoaned technological usage that is relegated to simple drill and kill-type procedures. In an effort to maintain cognitive mathematical fidelity, she called for a technological reformation of instructional software that promotes the higher levels of abstract thinking necessary for problem solving and advanced mathematical proofs.

Summary

Computer-based learning has emerged as a popular learning environment among constructivist educators who argue that students are at their best when they are allowed to take charge of their own learning (Chang, 2005). However, simply providing students access to technologically-enhanced courses is not favorable for those who lack the skills needed to regulate their own learning (Stillson & Alsup, 2003). In terms of instructional course redesign at the developmental level, access does not easily equate to success (Zavarella & Ignash, 2009).

With over 30 years of literature analysis, Shores and Smith (2010) warned that the research is rather limited as to internal and external factors affecting student performance in mathematics. Although learning strategies have long been considered vital contributors toward success in the traditional classroom, little research has attempted to show that the same productive learning strategies carry over into a technological learning environment.

What the literature has gleaned over the years is that remedial education is at its best when the principles of mastery learning and localization of control are incorporated into the instructional delivery (Hsien-Tang et al., 2008). Advocating Kinney's (2001b) mastery-laden developmental theory of self-regulation, Wambach, Brothen, and Dikel (2000) believe that developmental education students who continually self-regulate will be able to adequately identify those areas where their skills may be lacking - and find ways in which to improve them. Developmental education students who follow self-regulation strategies appreciate constructive feedback on their performance, develop a proactive conscientiousness about their grades, accurately predict their mathematical skill level, and use tutoring and other learning support systems when helpful. In short, Wambach et al. believe that developmental students must enhance their locus of control by taking responsibility for their own learning and other matters related to their academic success.

Wambach et al. (2000) continued by stating that Kinney's (2001b) developmental education theory is consistent with philosophies that demand students study and take tests on the material until they are able to demonstrate content mastery. In this manner, the emporium model of computerized instruction provides students with a responsive environment where students can receive on-demand, individualized help before moving on to the next unit. Finally, Wambach et al. promoted the use of computer-mediated instruction as a way to enable students to "take control of their own learning, develop a sense of self-efficacy, acquire good study habits and skills, and persist until successful" (p. 10).

As students devote more time on task through assessment *for* learning initiatives, cognitive learning and affective dispositions are likely to improve (Guskey, 2007). In theory, the pedagogical triumvirate of mastery learning, instant feedback, and diversified learning should dissipate the detrimental mental blocks of math anxiety (Smilkstein, 2003; Smith, 1998) while fostering a more intrinsic locus of control (Abu-Hilal, 2002); nevertheless, a gap in the research has been identified in which no study has linked the dependent variables of math anxiety and locus of control directly to a technologically-based mastery learning environment.

For the better half of the past decade, the National Center for Academic Transformation has emerged as a pioneer in institutionalizing mastery-learning concepts in large-enrollment, high-risk courses (NCAT, 2011). While many programs in search of positive change reap trivial benefits, Twigg (2011) has helped spawn scores of successful treatments through her redesign initiatives in which programs are encouraged to redesign entire courses rather individual sections. "Stop tinkering around the edges of change – if you want big results, you have to make big changes. If you want unnoticeable results, then continue making changes to the margins" (Twigg, 2011, para. 94). Technological course redesign is attempting to make very big changes in academic achievement, student completion, and student retention (NCAT, 2011).

A relative neophyte in journalized literature, the emporium-model redesign has yet to substantially populate the educational archives with experimentally-designed studies. While it would be difficult for oppositional arguments to confront and challenge findings of demonstrated success (Butler & Zerr, 2005; Hagerty & Smith, 2005; Hoon, et al., 2010; Witkowsky, 2008), one of the most notable criticisms of technology-based learning is that it is built upon the disconnect between educational design and application theories (Offer & Bos, 2009). Though the prospects of mastery learning, diversified learning styles, and instant feedback are certainly appealing from a designer's perspective, the successful application of instructional redesign could potentially be limited to isolated segments of the student population.

By their very design, Butler and Zerr (2005), Hagerty and Smith (2005), Hoon, et al. (2010), Miller (2010), and Witkowsky (2008) all focused their research studies on samples of college algebra students, who, for comparative purposes, are much further along in their cognitive development and academic maturity than students in developmental math courses (Hall & Ponton, 2005). From cognitivist and constructivist perspectives, developmental math students could have difficulty independently constructing their own mathematical knowledge if left to their own devices. To this end, it remains to be seen whether or not developmental math students in technologically-redesigned emporium model can experience the same positive academic results documented in the college algebra student population.

CHAPTER THREE: METHODS

Large-enrollment general education courses, particularly those at the developmental mathematics level, are becoming increasingly prone to failure (Boylan, 2005). A "lack of preparedness for college-level math courses is perhaps the foremost barrier to success in college. Students who repeatedly fail those courses take a beating academically, financially, and in terms of self-esteem" (Speckler, 2011, p. 96). In response, many university institutions have begun searching for cost-effective solutions to enhance and advance their students' educational experience through multi-faceted, technological redesigns of entire math courses. Though much of the recent literature has found computer-assisted instruction to be a significant contributor to academic success (Hagerty & Smith, 2005; Hoon et al., 2010; Kodippili & Senaratne, 2008; Witkowsky, 2008; Yesilyurt, 2010), the research has failed to address the question of instructional redesign at the *developmental* course level.

As a result, a quasi-experimental research design was employed to explore the effects of a technological course redesign solely on the population of developmental math students. Specifically, by running parallel sections of the course in both the emporium and lecture-based formats (Twigg, 2011), the research attempted to determine whether developmental math students who received instruction via the technologically-redesigned emporium model achieved significantly different completion rates, pass rates, and semester-to-semester retention rates compared to students in the same course who received instruction by traditional teacher-led methods.

In an increasingly technological age, teachers need to feel confident that computer-assisted instruction will not only provide a welcome diversion from the lecture-dependent classroom, but that instructional technology will also provide a legitimate means toward improving student learning. While the primary purpose of this study was to investigate the academic effects of redesigning large enrollment, lecture-style, developmental mathematics courses into self-paced, computer-assisted learning environments, the study allowed for a much-needed glimpse into the affective results of computer-dependent instruction, as well. According to the NCAT (2011), one of the hypothesized benefits of self-paced, technologically-enhanced course redesign is their ability to put students in control of their own learning in a manner that abolishes the feelings of anxiety that oftentimes befall students who have a storied history of struggling with mathematics. Therefore, the research investigated both the academic effects of technological course redesign in conjunction with students' affective responses in regards to anxiety and locus of control.

Design

In seeking to explain the educational implications of technological course redesign, the study was carried out using a quasi-experimental research design. Quasi-experimental research is typically denoted as a treatment/control experimental research design that lacks random assignment (Gall et al., 2007). Due to the impracticality and unethical practice of randomly assigning students to register for either the control or treatment sections of instruction, a quasi-experimental design is the only viable approach in most educational settings.

As such, a nonequivalent control-group quasi-experimental research design was used to investigate the emporium-model redesign phenomenon. The hallmark characteristic of the nonequivalent control-group design is that participants in both treatment and control groups are involved in taking a pretest and a posttest (Gall et al., 2007). The administration of two assessments, the Mathematics Apprehension-Anxiety Survey and the Internal-External Locus of Control Scale, thusly categorized the research as such a design.

Because students involved in the emporium model of instruction are asked to achieve a predetermined mastery level of 70% or higher before moving on to the next unit of material, it was assumed that students working towards mastery in the computer-based course would achieve a higher level of academic achievement than their lecture-based counterparts. Thus, the research in question was *not* whether technologically-supported students learn more, but whether or not they possess the gumption and fortitude to stick with the demands and impersonality of technologically-based instruction.

Research Questions

The research investigated both the academic effects of technological course redesign in conjunction with its affective responses to mathematics anxiety and internal locus of control through the following overarching questions:

1. Are developmental math students more likely to complete and pass their course in a mastery-learning, computer-based environment, compared to those students receiving instruction in a traditional teacher-led classroom?

2. Are developmental math students more likely to return to school the following semester after participating in a mastery-learning, computer-based environment, compared to those students receiving instruction in a traditional teacher-led classroom?

3. Are developmental math students more likely to report fewer sensations of mathematics anxiety and a heightened locus of control after participating in a mastery-learning, computer-based environment, that are not evidenced among those students receiving instruction in a traditional teacher-led classroom?

These guiding research questions were posed in the form of the following hypotheses:

Null Hypotheses

H_o1: Courses taught by way of a computer-assisted instructional redesign will not achieve significantly different completion rates than those taught by traditional methods of instruction, as evidenced by unofficial withdrawal (UW) and withdrawal (W) rates.

H_o2: Courses taught by way of a computer-assisted instructional redesign will not achieve significantly different pass rates than those taught by traditional methods of instruction, as evidenced by the proportion of letter grades issued as a C (or C- in some courses) or better.

H_o3: Courses taught by way of a computer-assisted instructional redesign will not achieve significantly different semester-to-semester retention rates than those taught by traditional methods of instruction, as evidenced by confirmatory enrollment the following semester.

H_o4: Students taught by way of computer-assisted instructional redesign or traditional methods will not report significantly different mathematics apprehension and anxiety levels at the end of the semester than were initially reported at the beginning of the course, as evidenced by pre-post scores on the Mathematics Anxiety-Apprehension Survey.

H_o5: Students receiving instruction by way of computer-assisted instructional redesign or traditional methods will not report significantly different levels of control at the end of the semester than were initially reported at the beginning of the course, as evidenced by pre-post scores on Rotter's Internal-External Locus of Control Scale.

Participants and Setting

As a whole, the target population of developmental education students encompasses a wide variety of socioeconomic backgrounds, ages, ethnicities, and educational histories that seamlessly converge at one particular unifying commonality: an underprepared and underdeveloped comprehension of basic skills that are requisite for success at the post-secondary level (Boylan & Bonham, 2007). Developmental education students receive remediation in core subjects such as English and mathematics that are typically supplemented with study skills workshops and academic success initiatives. As a population, developmental education students are considered “high risk” and are susceptible to failure, academic probation, and eventual attrition. To this end, countless educational interventions and programs have been spawned out of a glaring need to help developmental education students not only gain competence over basic skills and learning strategies, but also to encourage them to press onward toward the ultimate goal of college graduation (Boylan, 2005).

Therefore, representing the population of collegiate developmental mathematics students, the treatment and control samples consisted entirely of developmental math students enrolled at either of two mid-sized, four-year, open-enrollment universities participating in some form of computer-assisted instruction. The control group participants were taught in a traditional, teacher-led, instructional style while the experimental group participants received instruction in a self-paced, computer-based emporium model setting. In the custom of quasi-experimental research, the independent variable (instructional modality) was not manipulated, allowing students to freely register for the course section of their choosing (Gall et al., 2007).

The convenience sampling for this quasi-experimental design was conducted at two open-enrollment universities situated along the suburban benches of the Wasatch Mountain Range. Located seventy miles apart, the two institutions are demographical mirrors of each other in the sense that each university is a master’s-granting university that also serves and accommodates the under-qualified segments of its students as a result of their open admissions policies (Utah Valley University, 2013; Weber State University, 2013).

Consequently, as each institution pushes beyond 30,000 students, the number of under-prepared students in need of remediation vastly outpaces school-wide enrollment gains. The average incoming Freshman ACT math score for the two schools is 20 and 19, respectively. Students with an ACT math score below 23 are required to enroll in a developmental mathematics course, which translates into nearly three-quarters of all incoming freshmen at both schools taking at least one developmental-level course. Comparable student demographics reveal that both institutions express a large degree of homogeneity along other factors such as ethnicity (Caucasian) and age (average age at both schools is 24), all the way down to the large population of off-campus residents that define these two regionally-representative schools, with approximately 90% of students at both schools commuting to campus from home (Utah Valley University, 2013; Weber State University, 2013).

With a specific focus on developmental education courses, the research was conducted across mathematics courses that are routinely classified as remedial, or developmental, in nature. Pre-Algebra, Beginning Algebra, and Intermediate Algebra courses were all represented by adult participants as part of the research design and subsequent data analysis. Students who enter college ill-prepared to take a course in college algebra must first complete a sequence of developmental mathematics courses, pre-determined by the students' ACT, SAT, or placement examination scores, before advancing onto college-level mathematics. It is within this realm of remediation and student development that a distinct lack of research exists concerning emporium-model course redesign (Hodara, 2011).

In response to the growing costs associated with the need to educate an increasingly marginalized freshman class, each of the two schools began piloting technological redesigns of their developmental math courses in which instruction was delivered primarily through videos and software tutorials. While the treatment institution remained committed to a complete technological overhaul of their instruction of developmental mathematics, the control-group site maintained a focus on quality face-to-face classroom teaching initiatives.

Instrumentation

The emporium model of instruction is intended to take the focus off of passive learning in a manner that orchestrates an active, student-centered learning experience. To test this assumption, Rotter's (1966) Internal-External Locus of Control Scale (LOC) was used to determine the degree to which students feel they have control over their learning outcomes. In discussing the formulation of his locus of control inventory, Rotter (1990) developed a scale that could be generalized over a variety of situations, not just an academic context. The Locus of Control Test is a 13-item questionnaire that forces respondents to choose between two trains of thought. Scores range from 0 to 13, with a low score indicating internal control and a high score indicating external control (University of North Carolina-Charlotte, 2011).

Admittedly, Rotter (1990) contended that he never strove for a high alpha because he wanted to avoid asking the same questions over and over to a point of highly-reliable redundancy. Despite the potentially wide margin of error with only a 13-item inventory, Zerega, Tseng, and Greever (1976) were able to demonstrate test-retest reliability, as well as concurrent validity with a similarly valid measure, the MacDonald-Tseng scale.

Student anxiety levels were measured using the Mathematics Anxiety-Apprehension Survey (MAAS). Developed by former Grambling State Professor, T. Nelson Ikegulu (1998), the MAAS was designed to assess the levels of fear and apprehension that reside in mathematics students. While other anxiety inventories are more trait-based and meant to apply across a broad range of scenarios, Ikegulu purposefully developed an anxiety-apprehension survey that was situation-specific to the mathematics classroom. Scoring on the MAAS ranges from 40 to 200, with low scores referent to low levels of mathematical trepidation and high scores affiliated with high levels of mathematical anxiety and apprehension.

With an intermixing of positively- and negatively-worded statements, the face and content validity of the MAAS are directly evident from the question indicators themselves (Ikegulu, 1998). Many of the items in the MAAS are similar to items on other well-validated instruments such as the Mathematics Attitude Scale, Anxiety toward Mathematics Scale, and the Mathematics Anxiety Scale. Moreover, the MAAS has a proven track record of predictive validity for developmental math students in particular (Barham & Ikegulu, 1998). According to the study, developmental math students' final grades were significantly predicted based on the students' MAAS score and subsequent grouping into low, moderate, or high anxiety/apprehension levels.

In terms of instrument reliability, Ikegulu (1998) used several different reliability estimates in an attempt to strengthen the burden of proof and triangulate the overall reliability of the MAAS. Cronbach's alpha was used to assess the internal consistency, while Guttman's procedure computed the bounds for true reliability. Additionally, parallel form, strict parallel form, and Eigen-values were used to construct the instrument's total reliability measure. In sum, Ikegulu found that the negatively-worded statements from the MAAS had a Cronbach's alpha of 0.93 and the positive attributes scored a 0.85, with the bi-polarity of the responses reducing the global internal consistency estimate to 0.73 (0.74 when standardized).

Definition of variables

Course completion rates were determined by totaling the number of students actively participating up until the last day of the course. Those students withdrawing from the course before the officially designated deadline received a W, while students who stopped completing assignments and quit coming to class after the universities' official withdrawal deadline were awarded unofficial withdrawals (UWs) on their academic transcripts per University policy. Therefore, course completion rates were measured based on the number of students receiving a letter grade out of the total number of students enrolled in the course.

At the particular institutions where the study took place, passing letter grades of C or higher (C- in some instances) are awarded to students who score an overall average of 70% or better. Pass rates, therefore, were determined by the number of students who made a C or better (C- in some instances) out of the total number of students enrolled in the course.

The third learning outcome measured, semester-to-semester retention rates, was measured according to the number of students who enrolled in classes during the subsequent spring semester out of the total number of students who were enrolled the previous fall semester.

Procedures

In accordance with University policies and procedures, and based on the following considerations, the researcher submitted applications of exemption to Liberty University's Institutional Review Board (IRB), and to the Institutional Review Boards of the two participating universities. Conducted in an established educational setting, the research was in no way found to be injurious and did not subject students to any form of risk, whether physical, emotional, or academic. Student confidentiality and relative privacy was preserved by using student identification numbers to disaggregate student grades and enrollment status. Furthermore, in conducting a study based on samples of college students, none of the participants was under the age of 18, thereby foregoing the need to obtain parental consent. In this manner, informed consent was pursued from each individual participant directly (See Appendix A for Participant

Consent Form).

Once IRB approval was granted (see Appendix B for IRB approval letters), the research sought to identify a relationship between the independent variable (instructional modality) and the dependent variables (academic outcomes and affective measures). Emporium model completion rates, pass rates, and semester-to-semester retention rates were compared against the sample of students who received instruction via traditional, teacher-led methods. Alternatively, within-group differences were examined among both treatment and control participants through the use of the aforementioned MAAS and LOC pre-post surveys.

Outside of the typical required coursework, little was expected of the research participants. The only additional expectation asked of participants was that they fill out the mathematics apprehension and locus of control surveys during the first and fourteenth weeks of the semester. These pre- and post-test measures were used to determine whether or not the students' mode of instruction affected feelings of mathematical-based anxieties and personal ownership over their academic success.

Students enrolled in the traditional lecture-based courses attended class between two and four times per week (depending on the course), participated in structured class activities, completed assigned homework, and took quiz and examination assessments. Alternatively, students enrolled in the emporium model courses attended class once each week and received instruction from computerized videos and tutorials, as well as from face-to-face interactions with computer lab tutors and faculty. These students were allowed to retake quizzes and examinations until achieving a determined level of mastery of 70%. While the allowance of unlimited quiz and exam retakes inherently created higher achievement scores and grades, the course completion rates, pass rates, and retention rates data were extremely important in determining whether or not developmental math students have the motivation and self-discipline to pace themselves through a somewhat impersonalized manner of instruction.

Under the direction of a prepared script (Appendix C), participants were solicited from all possible developmental math classes through their individual course instructor. Participants were not given any type of monetary compensation or penalty in accordance with their participation or non-participation in the research surveys. Affective measures involving student locus of control and mathematical anxiety were collected at two separate points in time during the study; specifically during weeks 1 and 14 of the semester.

During the 14th, and final, week of the semester, the teachers in the lecture-based environment distributed and collected the post-test surveys exactly as they did in week one. However, since class in the emporium-model environment was held just once per week, the teachers within the emporium classrooms began distributing and collecting the surveys anytime between weeks 11 to 14 to ensure that all students had the opportunity to participate in the post-test round of surveys.

Only those students who successfully completed both rounds of surveys were included in the data analysis of affective outcomes. However, failure to complete both rounds of survey questioning did not eliminate the participant from the grade analysis at the conclusion of the semester. Effectively then, the course completion, pass, and retention numbers represented the entire sampling of consenting developmental math students, while the pretest-posttest data only included the subset of those participants who completed both rounds of surveys.

As such, 329 respondents from the control group (traditional lecture) consented to take part in the research study; however, roughly three quarters of those participating students properly completed both the pre- and post-test rounds of surveys. Specifically, 277 control group students completed both rounds of math anxiety surveys, while 266 participants completed both rounds of the locus of control surveys.

Conversely, from the treatment (emporium) group, 446 respondents consented to take part in the research study, with barely one-fourth of those participants properly completing the pre- and post-survey measures. One hundred nine of the course redesign participants fully completed both portions of the math anxiety survey while 105 participants completed both rounds of the locus of control survey. Table 4 shows the number of properly returned surveys among the participants, based on instructional model.

Table 4

Number of Consenting Participants and Survey Returns

	Lecture-Based Control	Computer-Based Treatment
Participants	329	446
MAAS Surveys	277	109
LOC Surveys	266	105

Students enrolled in traditional lecture classrooms had their grade data compared against those students who received instruction via the emporium model. Through faculty access to the Banner computer system, relegated faculty data managers looked up the final grades for all consenting participants for the semester and recorded the accompanying completion, pass, and retention data. This data analysis occurred three weeks into the following semester once full-time enrollment (FTE) numbers were made available so that retention data could be analyzed.

All pre- and post-test surveys were scored manually by the principle investigator. Original hard-copy surveys were stored in the principle investigator's personal filing cabinet while survey score results were tabulated in an Excel file on the principle investigator's personal laptop. All completion, retention, and pass rate information related to the research participants was also included in the Excel file.

Of note, at the beginning of the semester, faculty members received training on how to properly disseminate the MAAS and the LOC in an orderly and unbiased manner (Appendix D). After both rounds of assessment, the researcher personally collected the inventories from all faculty members.

Data Analysis

At the conclusion of the semester, the researcher gathered the student grade information compiled by each university's departmental data managers. Student grades were used to help determine completion rates and pass rates. After the third week of the following semester, once FTEs were finalized, the researcher again corroborated with each school's departments and recorded the number of participating students still enrolled in school during the subsequent semester.

In terms of data analysis, because the three academic outcome variables of interest (completion rates, pass rates, and retention rates) were represented as frequencies and percentages, a nonparametric chi-square test was used to analyze those data (Howell, 2008). All chi-square statistical analyses were performed by hand by the principle investigator. In conjunction with the chi-square test, effect size was calculated using the *d*-family measure of odds. As explained by Howell, odds relate to the frequency of success (such as course completion, pass, or retention) divided by the frequency of failure (course withdrawal, failure, and attrition). The resultant odds ratio was used to determine how many times more likely students in either the control or experimental group were to complete, pass, and stay the course in their mathematical journey.

Lastly, the repetitive pretest-posttest nature of the MAAS and LOC inventory results lend itself well to using repeated measures ANOVA to analyze the data. According to Gall et al. (2007), this statistical technique is used to determine whether pretest-posttest differences are reliably different within a group. A repeated measures ANOVA was effectively used in a study conducted by Azevedo and Cromley (2004) to determine that college students who received training in self-regulated learning techniques scored significantly higher on posttest material, even when the experimental and control groups both made sizeable gains in knowledge.

The sample-size demands that certain research designs require can oftentimes jeopardize the researcher's ability to run inferential statistics. However, in light of the two institution's open-acceptance admissions policy, finding a large sample of developmental mathematics students was rather attainable, with over 750 total student participants (n = 775) consenting to take part in the research process (Howell, 2008). As was the case with the chi-square analysis, the repeated-measures ANOVA was calculated entirely by hand by the principle investigator.

While prevailing educational theories might suggest that a new, innovative learning strategy would produce significantly higher results, giving way to a one-directional statistical analysis, this research and accompanying data analysis was conducted under the assumption that the effects of a full-scale, technologically-enhanced redesign of mathematics are unknown, and could unpredictably operate as either a benefit or a burden for developmental math students. Therefore, all statistical analyses were non-directional and conducted at a moderate .05 alpha level.

CHAPTER FOUR: FINDINGS

The purpose of this research study was to investigate the academic and affective outcomes of collegiate developmental math students (those students in need of remediation) who received instruction in an emporium model featuring computerized tutorials, e-texts, and one-on-one tutoring. Student completion, pass, and retention rates were compared between the sampling of participants who received instruction through a traditional lecture-based delivery and those who received instruction in the computer-based emporium medium. Psychological measures of mathematics anxiety and locus of control were also compared within the two groups.

The research hypotheses were developed under the construct that students who receive instruction through technological means are privy to the pedagogical advantages of mastery learning, instantaneous feedback, accommodating learning styles, assessment for learning, and self-paced academic ownership (Kohler, 2012). However, the research population of developmental students is oftentimes characterized as self-deprecating, lacking motivation, and in need of positive mathematical role models (Boylan & Bonham, 2007). As such, a study aligning the positive aspects of technological-based learning with a high-risk population such as developmental math students was needed to ascertain whether or not a technological course redesign of instruction is beneficial or burdensome for students with a case history of mathematical failure.

Results

Academic Hypotheses

Of the five hypotheses tested, the first three focused directly on students' academic outcomes within their developmental math course. Academic data was collected in the form of frequency counts and analyzed using a nonparametric chi-square test. Nonparametric tests are of statistical importance in that they do not rely on assumptions about the distribution or variance of population scores (Gall et al., 2007).

From an academic perspective, math courses have proven to be a stumbling block for developmental students as evidenced by consistently high rates of failure and attrition (Jacobsen, 2014). As such, the first hypothesis tested the dependent variable, course completion rate, in terms of the instructional-method independent variable.

Course completion rates. *H_o1: Courses taught by way of a computer-assisted instructional redesign will not achieve significantly different completion rates than those taught by traditional methods of instruction, as evidenced by unofficial withdrawal (UW) and withdrawal (W) rates.*

Course completion rates were determined by totaling the number of students actively participating up until the last day of the course. Those students who withdrew from the course before the withdrawal deadline received a W, while students who stopped participating in the course and quit coming to class were awarded an unofficial withdrawal (UW) on their academic transcripts per university policy. Therefore, course completion rates were calculated based on the number of students receiving a letter grade (non W or UW grade) out of the total number of participants enrolled in the study.

Of the 329 control-group students who agreed to participate in the study, 310 were able to work through to the end of the course, resulting in a 94.22% completion rate for lecture-based learners. In contrast, of the 446 computer-based participants, 344 persevered until the end of the course, or 77.13%. As seen in Table 5, a chi-square analysis revealed that the number of students who quit on the computer-based developmental math course was significantly higher than the quit-rate of the teacher-led lecture courses (* $p < 0.0001$); thereby rejecting the null hypothesis that instructional model and course completion rate are independent of one another.

Table 5

Chi-Square Contingency Table of Completion Rates

Instructional Model	Finished Course	Withdrew	Total
Lecture-Based Control	310 (277.634)	19 (51.366)	329
Computer-Based Treatment	344 (376.366)	102 (69.634)	446
Total	654	121	775

Note. Expected value in parenthesis. * $\chi^2(1) = 41.99$ ($p < 0.0001$)

The large chi-square critical value of 41.99, asserts that course completion rates within this study were definitely contingent upon the type of instruction received. A subsequent odds calculation yielded an odds ratio of 4.84, indicating that the odds of completing a developmental math course are more than four and a half times higher when students are taught at the hands of an instructor as opposed to a computer program.

Course pass rates. Though demonstrative of student fortitude and effort, course completion rates do not offer any insight into whether or not students adequately learned the required material. Therefore, a second measure of academic achievement, course pass rates, was analyzed over the instructional-method independent variable.

H_o2: Courses taught by way of a computer-assisted instructional redesign will not achieve significantly different pass rates than those taught by traditional methods of instruction, as evidenced by the proportion of letter grades issued as a C (or C- in some courses) or better.

Of those students who persevered until the end of the semester, only those students who demonstrated a 70% or better understanding of the material received a passing grade. At the two universities involved in the research, this amounted to a grade of C or better (in accordance with the grading scale at one of the universities, a C- grade in Pre- and Beginning Algebra landed above 70 percent, and therefore qualified as a passing grade).

The pass rate data fell along the same lines as the completion rate data, with 75.08% of the lecture-based students earning a passing grade, compared to 54.26% of computer-based learners. As shown in the chi-square contingency analysis of Table 6, students who received mathematical instruction in a traditional, teacher-led setting were significantly more likely to earn a passing grade than those students who struggled through the emporium model of technologically-focused learning (*$p < 0.0001$). Again, as was the case with course completion rates, the null hypothesis was rejected, indicating that pass rates in developmental math are contingent upon the type of instructional modality utilized.

Table 6

Chi-Square Contingency Table of Pass Rates

Instructional Model	Pass	Fail	Total
Lecture-Based Control	247 (207.588)	82 (121.412)	329
Computer-Based Treatment	242 (281.412)	204 (164.588)	446
Total	489	286	775

Note. Expected value in parenthesis. *$\chi^2(1) = 35.23$ ($p < 0.0001$)

Moreover, the data suggest a superior level of academic success for traditional lecture learners than with the computer-based emporium students, given a 2.45 course grade point average (roughly a C+ average grade) for lecture-based participants compared with a 1.83 course grade point average (approximates to a C- average grade) for computer-based participants. In terms of effect size, the resultant odds ratio of 2.54 indicates that students are two and a half times more likely to pass a development math course in a traditional lecture format than in an emporium model math course.

Student retention rates. Developmental math courses have long served as gateway, or bottleneck, courses that prevent under-prepared students from moving forward and realizing their dreams of attaining a college degree (Jacobsen, 2014). As such, a third academic measure, semester-to-semester retention rate, was analyzed in response to the instructional-method independent variable.

H_o3: Courses taught by way of a computer-assisted instructional redesign will not achieve significantly different semester-to-semester retention rates than those taught by traditional methods of instruction, as evidenced by confirmatory enrollment the following semester.

Table 7

Chi-Square Contingency Table of School Retention Rates

Instructional Model	Returned to School	Dropped Out of School	Total
Lecture-Based Control	262 (263.6245)	67 (65.3755)	329
Computer-Based Treatment	359 (357.3755)	87 (88.6245)	446
Total	621	154	775

Note. Expected value in parenthesis. $\chi^2(1) = 0.09$ is not significant at .05 alpha ($p = 0.7642$)

Table 8

Chi-Square Contingency Table of Math Course Retention Rates

Instructional Model	Took Math Again	Dropped Out of Math	Total
Lecture-Based Control	209 (212.6826)	120 (116.3174)	329
Computer-Based Treatment	292 (288.3174)	154 (157.6826)	446
Total	501	274	775

Note. Expected value in parenthesis. $\chi^2(1) = 0.31$ is not significant at .05 alpha ($p = 0.5777$)

Though course completion and pass rates were decidedly one-sided in favor of lecture-based learning, the student retention data revealed no significant difference between instructional models in terms of both school and math course retention. With 79.64% of control-group students returning the following semester compared to 80.49% of treatment participants, both institutions witnessed a nearly identical proportion of students enrolled in school the following semester.

Similarly, students' mathematical persistence was not a statistically significant variable for either instructional model. Although the lecture-based control group witnessed a significantly higher proportion of passing students, only 63.53% of those control-group participants re-enrolled in a math course the following semester, compared to 65.47% of emporium-model participants. While the emporium model produced a slight edge in the proportion of returning math students, a chi-square data analysis revealed that the two percent difference in mathematical retention rates was more likely a consequence of chance, and not attributable to instructional modality. Therefore, of the three academic variables, chi-squared data analyses established that course completion rates and pass rates were significantly contingent upon the type of instructional model, whereas student retention rates were not.

Affective Hypotheses

Equipped with the ability to invoke mastery learning, provide instant feedback, and appeal to an array of learning styles, computerized instruction offers the potential of not only helping collegiate math students perform better in their courses, but to improve along several psychological measures as well (Smilkstein, 2003). For the purpose of this research study, two affective measures, math anxiety and locus of control, were analyzed to determine whether or not students subjected to the learning assistance of a computerized emporium model of instruction had their fears allayed and took more ownership of their learning over the duration of the researched semester.

Before conducting a repeated-measures ANOVA on the affective survey data, assumption tests for normalcy and homogeneity of variance were performed in order to first establish that all collected data was normally distributed about the mean, and that the groups of data had statistically similar variance. Statistical tests of skewness and kurtosis both fell within two standard errors, indicating that the data was indeed normally distributed, while an F-distribution statistic was used to conclude that the variances of the research groups were equal (Zaiontz, 2015).

Mathematics-related anxiety and apprehension. *H_o4: Students taught by way of computer-assisted instructional redesign or traditional methods will not report significantly different mathematics apprehension and anxiety levels at the end of the semester than were initially reported at the beginning of the course, as evidenced by pre-post scores on the Mathematics Anxiety-Apprehension Survey.*

Paramount among the concerns of developmental math students is the palpable feeling of anxiety that becomes manifest during class time, especially during testing (Smilkstein, 2003).

To evaluate the dependent variable of mathematics apprehension/anxiety, students were given the Mathematics Anxiety-Apprehension Survey during the first week of the semester, and again within the final week of semester to evaluate whether students' mathematics fears remained, lessened, or intensified as a result of the instructional-method independent variable.

Of the 329 students who agreed to participate in the lecture-delivery control group, a little more than three-quarters (277) of the participants fully completed both the pre- and post-survey rounds of questioning. In contrast, roughly one-in-four participants of the emporium model treatment group (109 out of 446) completed usable survey data. The descriptive statistics shown in Table 9 indicate that the average of all of the participants, regardless of school affiliation or instructional model, came out nearly identical in their scoring – separated by only a single point on the pre-test. According to the MAAS, scores range from 40 to 200, with low scores indicating a veritable absence of math-related anxieties, while a high score would characterize a student with extreme mathematical fears. With an overall mean of 111.90, both sample groups typified the developmental math student archetype with moderate levels of mathematics-induced anxiety. However, as Table 9 also displays, the overall anxiety levels rose slightly among the emporium participants while dropping an average of six points among lecture learners.

Table 9

Descriptive Statistics of Mathematics Apprehension-Anxiety Survey

		Pretest		Posttest	
Instructional Model	n	Mean	SD	Mean	SD
Lecture-Based	277	111.61	22.50	105.27	23.475
Computer-Based	109	112.63	25.92	112.90	24.078
Total	386	111.90	23.48	107.42	23.865

To determine whether the emporium model's relatively static pre- and post-survey scores were statistically significant, a repeated measures ANOVA was conducted on the data. As shown in Table 10, the resultant F-value of 0.03 fell far below the statistically significant value of 3.94 needed in order to show that the emporium model's instructional delivery could help reduce math-related fears ($p = 0.8603$).

Table 10

Repeated-Measures ANOVA of Computer-Based Apprehension/Anxiety Scores

Source	df	SS	MS	F
Subjects	108	121,398.8188		
Observations	1	3.9732926371	3.9732926371	0.0311
Error	108	13,782.77671	127.6183029	
Total	217	135,185.5688		

Note. F-value is not significant. $F_{.05}(1, 108) \approx 3.94$ ($p = 0.8603$)

On the other hand, the lecture group's six point reduction in anxiety scores over the course of the semester was able to produce a significant outcome (See Table 11). According to the repeated measures ANOVA, students who received face-to-face, teacher-led instruction reported significantly less mathematics-related apprehension and anxiety at the end of the year compared to when the class first began ($^*p < 0.0001$). In terms of effect size, lecture-based students' MAAS post-test scores were 0.28 standard deviations lower than their pre-test results.

Table 11

Repeated-Measures ANOVA of Lecture-Based Apprehension/Anxiety Scores

Source	df	SS	MS	F
Subjects	276	258,586.0388		
Observations	1	5567.096192	5567.096192	46.3104*
Error	276	33,178.65381	120.2125138	
Total	553	297,331.7888		

Note. F-value is significant. $^*F_{.01}(1, 276) \approx 6.74$ ($p < 0.0001$)

Although the lecture-based control group reported significantly lower feelings of math anxiety by the end of the year, while the computer-based treatment group did not, the repeated measures ANOVA is not a between-subjects design. A repeated measures ANOVA can only compare pre- and post-tests within the same group, and not across groups (Howell, 2008). With this limitation in mind, a pooled-variance t-test was conducted on the post-test scores across the two groups to establish further validity of the lecture-based groups' decreased anxiety levels. A two-tailed t-test confirmed a significant difference between the control and treatment groups' end levels of anxiety ($t = 2.8538$; $\alpha < .01$). Using a pooled variance, students in the computer-based emporium model reported end-anxiety levels that were one-third of a standard deviation higher than students in the lecture-based courses.

Furthermore, using the calculation of a confidence interval with 95 percent certainty, students who received instruction through the computer-based emporium medium scored, on average, between 2.39 and 12.87 points higher on their post-survey anxiety measures. Therefore, the null hypothesis is rejected; students who attended a developmental math course taught by teacher-led lecture did in fact report lower levels of mathematics anxiety and apprehension at the end of the semester than was reported in the beginning, which were also significantly lower anxiety levels than students who received instruction through the emporium model.

Localization of control. *H_o5: Students receiving instruction by way of computer-assisted instructional redesign or traditional methods will not report significantly different levels of control at the end of the semester than were initially reported at the beginning of the course, as evidenced by pre-post scores on Rotter's Internal-External Locus of Control Scale.*

Rotter's Internal-External Locus of Control Scale contains 13 items, each containing two dichotomous statements. One statement expresses the point of view of someone with a strong internal predilection for handling their affairs, while the other statement takes on the role of someone who places external blame on uncontrollable circumstances. Participants were scored for every external argument they agreed with, finishing with a score between 0 and 13. Lower scores inversely correspond with higher feelings of control, while high scores are indicative of external blaming and feelings of helplessness (Rotter, 1966).

By shifting the responsibility of instruction from the teacher to the student, it was anticipated that computer-assisted learning would have a profound effect on redirecting students' locus of control. However, upon completion of the data analysis, the results between the two groups were virtually identical in both the pre-test survey and again at the end-of-semester post-survey.

As shown in Table 12, the parity between treatment and control groups was evident in that the descriptive statistics were identical until calculated out to the hundredths place value. Both groups lowered their mean locus of control from 4.2 down to 4.1 over the duration of the semester. However, like the MAAS returns, the traditional lecture-based participants reported a return rate of over 80 percent (266/329) while only 105 out of the 446 computer-based participants (less than 25 percent) successfully completed both rounds of the locus of control survey.

Table 12

Descriptive Statistics of Locus of Control Survey

		Pretest		Posttest	
Instructional Model	n	Mean	SD	Mean	SD
Lecture-Based	266	4.2857	1.983	4.1654	2.086
Computer-Based	105	4.2286	1.943	4.1143	1.973
Total	371	4.2695	1.969	4.1509	2.052

With such minimal variation within the groups' pre- and post-survey scores, there was little doubt that the repeated measures ANOVA would fail to show any significant results. As expected, the statistical analysis in Table 13 tabulated an F-value of 0.35 for the computer-based treatment group, which fell below the 3.94 F-value necessary to tie any significance to the emporium model's results (p = 0.5569).

Table 13

Repeated-Measures ANOVA of Computer-Based Locus of Control Scores

Source	df	SS	MS	F
Subjects	104	591.82857		
Observations	1	0.6858858	0.6858858	0.347429
Error	104	205.31411	1.974174135	
Total	209	797.8285658		

Note. F-value is not significant. $F_{.05}(1, 104) \approx 3.94$ (p = 0.5569)

Similarly, data from Table 14 involving the lecture-based control group failed to reveal any statistically significant changes between pre- and post-survey scores. Though a slightly larger F-value of 1.13 was calculated for the control group, it did not meet the 3.88 standard that was necessary to determine statistical significance (p = 0.2896).

Table 14

Repeated-Measures ANOVA of Lecture-Based Locus of Control Scores

Source	df	SS	MS	F
Subjects	265	1741.932331		
Observations	1	1.924788067	1.924788067	1.125792858
Error	265	453.0752119	1.709717781	
Total	531	2196.932331		

Note. F-value is not significant. $F_{.05}(1, 265) \approx 3.88$ (p = 0.2896)

With neither group being able to demonstrate significant locus of control differences between pre- and post-survey scores among their own participants, a t-test was run to try and determine any statistical differences between computer- and lecture-based participants' end-of-semester feelings of control. With both groups' means being nearly identical, the t-test also failed to reveal any statistical differences between the two groups (t = -0.2158). Therefore, the null hypothesis cannot be rejected. Students who received instruction via the computer-based emporium redesign model did not report different levels of control (neither higher nor lower) from the beginning of the semester to the end, nor were their reported levels of control statistically different than their lecture-based counterparts.

CHAPTER FIVE: DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Discussion

With digital access to the pedagogical philosophies of mastery learning, instant feedback, self-regulation, and multiple learning styles, the appeal of an emporium-based model of computerized learning has begun to emerge within higher education circles. In particular, the appeal of streamlining and lowering the costs of large-volume courses has already proven beneficial among a host of mathematics courses (NCAT, 2011). Since converting over to a computerized emporium-model of instruction for their mathematics courses, Virginia Tech has seen pass rates improve from 74.8% to 83.6%, while dropping costs from $91 per student to $21 (Olsen, 1999). Similarly, in recounting the success of the University of Idaho’s conversion to an emporium model of mathematics instruction, Miller (2010) reported that the number of students who either withdrew from class or failed has dropped by 20 percent.

While the emporium model of computerized instruction has been an instructional and financial boon for these college-level math courses, educators should be wary of misinterpreting population samples by endorsing the implication that an effective model of instruction for *college-level* mathematics translates into a similarly effective model for *pre- and beginning-algebra* students (Kohler, 2012), given that calculus students possess more mathematical skill than developmental students – and – in doing so, have a much more powerful belief in their ability to succeed in college mathematics (Hall & Ponton, 2005). In searching out the effectiveness of a computerized-based model of instruction strictly on samples of developmental math students, much of the literature fails to maintain its rigor and relies too much on anecdotal observations, with the lack of empirical evidence making computer-based findings inconclusive as a whole (Hodara, 2011). On this: "There is very little empirical research on this topic and population specifically" (p. 3).

Therefore, this research study sought to determine whether or not a computer-based emporium model of instruction is academically and affectively preferable to a traditional lecture-based model of instruction within the population of developmental mathematics students. Using a quasi-experimental method of design, the research investigated this question by analyzing completion rates, pass rates, and retention rates between students in traditionally-taught developmental math courses and a comparable set of students receiving instruction via computer-based tutorials, e-texts, and one-on-one student-faculty interactions. Additionally, affective/psychological differences between the two groups were assessed using pre-test/post-test analysis of two surveys: the Math Anxiety and Apprehension Survey and a Locus of Control survey.

Summary of Findings

A nonequivalent control-group quasi-experimental research design was used to investigate the effects that a computer-based emporium model of instruction would have on a sample of developmental mathematics students. Prior to the researched semester, participants enrolled in one of two possible instructional formats, dependent upon which university they were attending. The control group participants attended a university in which developmental math course sections are taught primarily by face-to-face lecture, with some technological supplements assigned as homework activities; whereas the treatment group participants attended a university that offered developmental math courses solely in an emporium model of instruction.

Zhu and Polianskaia (2007) defined the traditional lecture format as a pedagogy in which the instructor plays the central role as a diffuser of information through organized lectures. In holding to this definition, the instructors at the control group university also augmented their lectures by asking students engaging questions and answering students' questions. Additionally, instructors provided practice problems from a course-specific computer software program for students to complete as homework after a new concept or skill was introduced. In most cases, depending on the skill or comfort level of each instructor, the lecture-based control group also benefited from a myriad of collaborative in-class learning activities.

Instead of human interaction, the treatment group's instructional focus was centered on technology. With multimedia at the forefront of this instructional modality, the teacher's role shifted from an omnipotent sage on a stage to an omnipresent computer lab facilitator. With an increased sense of personalized mobility, instructors were tasked with moving about the computer lab during the entire class period to provide assistance, when requested. Though students learned primarily at the hands of video tutorials, e-text readings, and computerized simulations, the instructor was present in class and in the computer lab to clarify a video's explanation of a concept, to aid in troubleshooting errors, or to discuss with students their individualized course progression so that they could remain on track. With a course management system providing such detailed information about each student's progress, the instructors were able to quickly identify those students most in need of assistance (Zhu & Polianskaia, 2007).

During the first week of the semester, participants were asked to complete two surveys: the Mathematics Apprehension and Anxiety Survey and the Internal-External Locus of Control survey. From that point, participants progressed through the course either independently self-paced through the emporium model of instruction, or by lock-step guidance via face-to-face, whole-class lectures. At the end of the semester, participants were again asked to complete the same math anxiety and locus of control surveys that they had been asked to complete during week one.

As the primary means of differentiation between the two groups, instructional modality acted as the independent variable of this research study, with three academic and two affective measures serving as dependent variables. For all three academic analyses a chi-square test was used to determine whether or not developmental math students who received instruction through the emporium model completed the course, passed the course, and were retained in mathematics courses the following semester at higher proportions than those students who were taught under a traditional lecture-based regime. Affectively speaking, a repeated measures analysis of variance was employed to determine whether or not emporium-model students fared better psychologically at the end of the semester then they did at the beginning, as evidenced by scores on the math anxiety and locus of control pre-post surveys.

Though equipped with an impressive pedagogical pedigree formulated to improve academic outcomes and mitigate psychological concerns associated with mathematics anxiety and locus of control, the emporium model's silver bullets of mastery learning, instant feedback, personalized tutoring, appeal to learning styles, self-pacing, and autonomy did very little to stifle the beast of developmental mathematics failure. In fact, not only did the research data fail to yield any significant results in favor of an emporium model of instruction, the unforgiving data could not even manage to keep the conversation null through three of the five tested hypotheses.

Statistically, students who attempted to complete a developmental math course through the emporium model completed the course at a significantly lower rate, passed the course at a significantly lower rate, and finished with a significantly higher level of mathematics apprehension and anxiety than their control-group counterparts. Of the five investigated dependent variables, only the null hypotheses concerning the academic measure of student retention and the affective measure of localization of control could not be rejected.

By shifting the responsibility of instruction from teacher to student, it was anticipated that computer-assisted learning would have had a profound effect on redirecting students' locus of control. Under an emporium-model course redesign, students were no longer subjected to "mean" teachers who graded too harshly, "easy" teachers with laissez-faire attitudes, anxiety-inducing time constraints on tests, or any other undue burden that fell outside of students' direct control (Rotter, 1966). By shaping and grooming students' internal locus of control, it was anticipated that students would, in turn, become more excited about their educational endeavors, return to school with greater frequency, and feel better about the quality of their education, confident in their newfound ability to master the required curriculum (Abu-Hilal, 2002).

Instead, the dependent measure of locus of control proved to be a statistical stalemate, as treatment and control groups reported nearly identical feelings of internal control on both the pre- and post-semester surveys. The anticipated shaping and grooming of students' internal locus of control never materialized at the hands of the computerized instruction, and in turn, the projected feelings of mathematical excitement, course participation, and demonstrated knowledge never came about for students in the emporium model. In fact, the data showed that the emporium model of computerized instruction acted as more of a detriment to student psyche and student learning in three of the five tested variables.

As stand-alones, the research-based practices of mastery learning and locus of control have been shown to produce astoundingly positive effects (Parkay et al., 2010) that it is quizzical, and even confounding, as to why a computerized model of instruction based upon the principles of concept mastery and student autonomy would generate such negative results. In a mastery learning environment, the more time that students are allotted to digest, try, and re-apply information, the greater the improvement in, not only understanding, but in a wide variety of affective measures as well (Guskey, 2007). What actually transpired, however, was an increase in mathematical anxiety, a decrease in school attendance and class involvement, and an overwhelmingly estranged feeling between students and their emporium-model courses.

Similarly, in a technologically-based model of instruction, increased student autonomy and self-direction was supposed to translate into the elimination of down time between classes and manifest itself in the form of more student time on task (Squires et al., 2009). Under the emporium model of instruction, it is theoretically feasible for students to complete more than one developmental course in a single semester, or at least get a head start on the next course in the developmental sequence. "In other words, accelerated students are not hindered by a teacher's pacing…but are in complete control of earning whatever grade they desire in the amount of time that they require" (Kohler, 2012, p. 28). According to the grade distribution of emporium model participants, the highest proportion of students elected to adhere to this "time on task" mission by putting in the time and effort to earn a desirable grade, with 91 students (roughly 20%) earning a B and another 69 students (15%) making a grade of B+. Unfortunately, that is where the positive data ended. Following the B and B+ grades, the next four highest grade distributions among emporium model participants were UW (15%), D (13%), E (10%), and W (8%).

While the grade data certainly revealed a significant portion of the emporium model's detriment, Gladwell (2008) refuted that grades and achievement should not entirely define a successful student. Rather, Gladwell contended that being good at math is not so much about ability as it is attitude; that the only way to lead to mastery is if one tries; and that success is a function of persistence and determination. Even for slower-paced students - those participants who were unable to complete the required number of modules to pass the course - the emporium model allows for them to resume exactly where they left off the following semester, thereby incentivizing students to persist in their developmental course sequence and return to school with greater frequency (Squires et al., 2009). Unfortunately, the emporium model retention data, though descriptively better than the lecture-based group, was not significantly affected by the availability for students to pick up where they had previously left off, with both institutions essentially producing equal proportions of school drop-outs and mathematics avoiders. Consequently, the current research did more to prove the converse of Gladwell's theories regarding student perseverance and locus of control through repeated, negative statistical outcomes. The research data syllogistically deduce that emporium students' significantly poorer mathematical attitudes and festering apprehensions gave way to a lack of effort and persistence as evidenced by significantly lower completion rates and pass rates, coupled with inconclusive retention data.

Conclusions

Identifying the Disconnect

Featuring promising pedagogy and streamlined software technology, the emporium model of instruction ultimately proved to be a failed endeavor, with three of the five tested variables producing significantly negative results (completion rate, pass rate, and self-reported math anxiety measures). In light of this research data, a careful rumination of the research literature illicit several conjectures as to why and how such a promising vehicle of instruction crashed and burned in its implementation. In rendering deleterious academic and affective outcomes, it appears that the emporium model of computerized instruction failed to address concerns regarding the population of developmental students, mismanaged student and faculty expectations, and unsuccessfully assuaged real psychological barriers, such as math anxiety, that impede the natural learning process.

The developmental population. It is difficult to ignore the fantastic gains that emporium-model institutions have witnessed first-hand (Miller, 2010; NCAT, 2011; Twigg, 2011; & Witkowsky, 2008), as their successes with college algebra and calculus populations are often used as evidence to suggest that computer-based instruction is superior to more traditional models of teaching. However, developmental educators must be wary of the implication that an effective model of instruction for higher level math courses automatically translates into a similarly effective model for pre- and beginning algebra students (Kohler, 2012). Even the demonstrated success of emporium models with developmental math students, such as those reported at Cleveland State Community College (Squires et al., 2009; Stern, 2012) can only draw tangential lines of comparison considering that the two universities studied in the current research project are nearly ten times the size as the intimate and more personable setting offered at CSCC.

Despite the broad demography that makes up the population of developmental learners, Boylan et al. (1999) characterize them through several high-risk sub-categories such as non-traditional, disabled, ignored, limited English fluency, users, poor choosers, or the most likely scenario, a combination of two or more of the preceding descriptors. As a result, developmental students have less mathematical efficacy and ability than calculus students (Hall & Ponton, 2005). This idea that higher-level math students possess a more powerful belief in their ability to succeed in higher education speaks volumes in behalf of research attributed to self-efficacy. In studying the learning behaviors of students enrolled in a computer-based developmental math course, Wadsworth et al. (2007) found that self-efficacy accounted for the single largest variance in mathematical achievement. Therefore, in a technologically-centered environment, those students with low feelings of self-efficacy are more prone to avoidant behaviors such as absenteeism and withdrawal (Kohler, 2012).

Cognitively and psychologically speaking, the emporium model does not bode well for developmental students who have experienced a lifelong struggle, avoidance, and even hatred of math. Tasked with formulating their own understanding of mathematical principles through impersonal videos and screenshots, developmental math students have demonstrated avoidant coping strategies time and time again when it comes to instructional technology. Confirming the phenomenon of developmental-student recoil from computer-based instruction, Zavarella and Ignash (2009) found that students in a hybrid developmental math course that featured online instruction were twice as likely to withdraw as lecture-based students - adding credence to the current study's findings in which emporium model students were nearly five times more likely to withdraw than teacher-led learners. Similarly, Spradlin (2009) was unable to run inferential statistics on data from her experimental online groups due to the high level of attrition in those sections; while Xu and Jaggars (2011), using statewide administrative data, confirmed a largely negative impact for students working in online-based mathematics courses.

In specifically researching the effects of computer-mediated classrooms on the population of developmental math students, Zhu and Polianskaia (2007) found similar negative trends concerning the completion and pass rates of technological learners. Over a ten year period of time, completion rates were generally higher in the lecture classes, while course pass rates statistically favored the lecture-based students as well. In sum, computer-mediated instruction cannot substitute for traditional, teacher-led instruction in the developmental mathematics classroom.

Cited among the literature as a potential advantage for computer-based instruction (Rotter, 1966; Weiner, 2003), it appeared as if increased levels of autonomous control and self-pacing plagued developmental students with an astonishing level of freedom that few were capable of handling (Kohler, 2012). Developmental students are high-risk students, and whether that risk stems from a history of poor decision making or simply dealing with the stresses of an over-occupied adult, the increase in freedom that the emporium model advertises further challenges those students who lack the time-management skills and necessary discipline to handle this new-found freedom. For those developmental students who have a history of mathematical struggles or sailed through high school under the mantra “D is for diploma,” requiring them to learn by pushing them into an e-text is not enough to correct years of deficient academic habits.

Mismanagement of student and faculty expectations. Of course, not every student placed into the developmental math track is devoid of disciplined time-management skills and self-efficacy. A number of students who place into developmental mathematics are simply out of practice and in need of a quick refresher of basic algebraic concepts (Boylan et al., 1999). This minority of developmental students are the ones who are capable of benefitting most from a self-paced, self-directed model of learning.

With students directly in control of how fast they complete the course, it is feasible for students to complete more than one developmental course in the same semester (Stern, 2012). Though it is unknown how many students in the researched emporium model took the initiative to complete some degree of work in a subsequent course, not one of the 446 computer-based participants successfully completed more than one course during the semester. This lack of multiple course-finishers is significant in light of the fact that, in adopting the emporium model, the university consequently disbanded “fast track” courses that merged coursework from two successive courses - such as Math 0950 and Math 0990 being blended together to create one 6-credit-hour course called Math 0980, or converging Math 0990 and Math 1010 concepts to create Math 1000.

The control group, on the other hand, continued to support and strengthen their fast track courses, thereby creating an expedited course sequencing that allowed more than 50 of the control-group participants (15%) to essentially leapfrog more than one math course on their way to meeting their quantitative literacy requirement. As a result, the emporium model not only negatively impacted students’ persistence and grades data, but it also erected unforeseen barriers in terms of students’ mobility and progress through multiple courses.

In the state where the current research study was conducted, Jacobsen (2014) reported that 47 percent of that state’s college students graduate within six years of first enrolling; ranking them 39th in the nation. Not surprisingly, the most cited roadblock that prevented students from graduating was developmental coursework. The longer students are enrolled in the developmental math sequence, the less likely they are to graduate. The solution, according to Epper and Baker (2009), is acceleration. Noting this distinct negative correlation between time spent in developmental math and earning a college degree, they recommend more accessibility to fast track options such as those offered at the lecture-based university.

Further statewide data revealed that, on average, 41 percent of the state’s college freshmen who enrolled full time did not return the following school year (Jacobsen, 2015). While the emporium model attempted to reverse attrition rates among its developmental population by allowing students to continue working in the course where they had previously left off, Jacobsen reported that student attrition may be linked to an entirely different variable than what the emporium model is attempting to address. According to student surveys, Jacobsen found that the biggest challenge that developmental students face is the balance between studies, work, and family - with financial concern cited as the primary contributor to attrition, not academic ability. Regarding the issue of retention, as developmental students navigate their academic lives, they quickly find that the biggest obstacle in life to overcome is life itself.

While the ideal of emporium-model learning advertised that students could readily complete more than one course offering in a single semester, the 0 out of 446 reality of that claim demonstrates just how glaringly the emporium model failed to live up to certain advertised student and faculty expectations. Frustrations mounted while students and faculty alike grew jaded over intangible barriers, newly defined roles, and anticipated personal connections between students and faculty that never materialized.

In this study's emporium model, students were required to spend several hours each week in a centralized tutoring center to ask questions and to receive personalized help from faculty members. To incentivize students to attend, attendance was tracked using student login information from the computer lab and recorded as 10% of the students' grade. With one-on-one human interactions being billed as the fundamental foundation of formal instruction (Robinson, 1995), students were promised an effective technological learning environment in which student-faculty interactions could take student understanding beyond what was taught from the computer tutorials and videos. However, the unforeseen reality of the emporium model quickly discouraged students from attending the tutoring lab, as the sheer number of students in need of help at any given time reduced the quality and quantity of personalized teacher-student interactions. The overwhelming demands of discouraged, stuck, and confused developmental students on the small handful of faculty forced the emporium-based institution to ultimately counsel its faculty members to spend no more than one minute in helping students before moving on. As unintentional as it may have been, such restrictions transmitted a message of contempt towards students who were truly in need of human support.

Conversely, faculty members in the emporium model have had to adjust to a restructured role; one that is radically different from the job description that originally drew educators into the field of developmental mathematics. On this topic, Miller (2010) openly questioned whether instructors' redefined roles within an emporium model infringe upon the academic freedoms of tenured faculty, as instructors found their involvement in the emporium model to be quite limited to that of a qualified peer tutor or graduate assistant, watching the clock, and existing from shift to shift (Kohler, 2012). Faculty members were forced to reconcile between their former duties of preparing dynamic lessons and their emporium duties of tracking student progress. Patience was tried as instructors answered the same questions countless times each day.

Illustrative of the potential for faculty frustration and ennui were complaint documents filed against an emporium-model faculty member, connecting her to a case of academic fraud. Williams and Koos (2014) reported that the developmental math faculty member took quizzes and exams for five football players in order for them to pass the course. When asked why she took the exams and quizzes for the students, the faculty member succinctly indicted the emporium model for ruining her desire to teach and acknowledged that she was burned out and no longer satisfied with her job.

Failure to reduce anxiety. In the current research study, the emporium model's failure to align with the expectations and needs of a high-risk developmental student population was evident in that attitudes and apprehensions related to mathematics and mathematics instruction were not mitigated in a way that was statistically prevalent in the lecture-based control group. Simply stated, students who received their instruction at the hands of a qualified teacher significantly lowered their anxiety toward mathematics, while those students who received their instruction via video tutorials and minute-long conversations with faculty members reported no signs of relieving their math-related fears.

The results of the current study corroborate the findings of a dissertation that also examined the effects of an emporium model on student attitudes and achievement. Using ANCOVA on pre- and post-measures of the Attitudes toward Math Inventory, Bishop (2010) determined that the control (lecture) group self-reported greater dispositions regarding math compared to the computer-based treatment group. Despite the mastery-based emphasis placed on the emporium model students, Bishop was unable to identify any significant difference in achievement, based on common assessment pre- and post-test scores.

Many students who lack confidence in their ability to do math feel apprehensive about doing simple mathematical tasks. As a result, a detrimental cycle is created where poor mathematical performance spawns mathematical avoidance (Smith, 1998). Avoidant coping strategies cause students to remain deficient in their mathematical knowledge, thus perpetuating a cycle of lackluster performance, avoidance, and anxiety that kept 41 percent of developmentally-laden college freshmen from returning to school between 2012 and 2013 (Jacobsen, 2015).

Math is a discipline that requires students to demonstrate procedural knowledge, as opposed to declarative knowledge. Therefore, students who approach math with a memorized, rehearsal-based learning strategy are more prone to struggle with step-by-step-oriented problems

(Kesici & Erdogan, 2009). Like learning strategies, particular learning styles are also susceptible to bouts of math anxiety. Mathematics is a kinesthetically-intense subject, replete with practice and repetition, which caters to hands-on learning styles. As a result, students who are accustomed to using a global learning style, also referred to also whole picture learning, are more likely to develop feelings of inadequacy and anxiety (Gresham, 2007).

In implementing the emporium model, it was pre-supposed that developmental students' apprehensive tendencies and anxieties would be absolved through concurrent mastery of the subject material (Smith, 1998). However, the failure of emporium-model students to lessen their apprehensions and anxieties toward mathematics, despite an increase in content mastery, shed light on several affective theories contending that mathematical aptitude does not necessarily equate to a lack of mathematical anxiety (Walsh, 2008). Asian countries such as Korea and Japan that are worldly renowned for their mathematical achievement, consistently demonstrate low math self-concept and self-efficacy, coupled with high levels of math anxiety, in spite of their remarkably high performance scores (Lee, 2009).

In researching the manner in which certain demographics either live up to, or play down to, perceptual stereotypes, Gladwell (2009) reported that cultural and academic sub-groups, who are consistently subjected to increased levels of pressure, significantly conform to perceived stereotypes in ways that are not evident when increased expectations are present. Gladwell concluded that pressure causes performance to suffer, and has found that pressure applies most in situations where groups are often depicted in negative ways, such as at-risk developmental math students. This failure, Gladwell contends, is attributed to choking, not panic. Choking is when one reverts back to explicit memory functions and tends to over-think the process – as opposed to panic in which instinct sets in and narrows one's focus.

When a student in the emporium model fails to attain 70 percent or higher mastery on a given quiz or test after multiple attempts, the common remedy requested by the instructor is to counsel the student to buckle down and take the test more seriously. Unfortunately, this is the exact problem with choking – the students are taking it too seriously and over-thinking the process, failing to allow the fluidity of all of their hard work and practice to take over (Gladwell, 2009). These students are prone to second-guessing. They feel they did really well because they thoroughly analyzed each problem, but that in turn may be their particular downfall, as "sometimes a poor test score is the sign not of a poor student but of a good one" (p. 278). Of the five significant learning strategies studied by Wadsworth et al. (2007), the only one to manifest a negative correlation effect was self-testing, indicating that more self-testing resulted in worse computerized math performance. As noted by Gladwell, these students

> "failed because they were good at what they did: only those who care about how well they perform ever feel the pressure of 'stereotype threat.' The usual prescription for failure – to work harder and take the test more seriously – would only make their problems worse." (p. 277)

Identifying the Solution

Although emporium-model developmental math programs may benefit from increased student achievement by requiring students to pass all tests and quizzes at a 70% mastery level, they ultimately risk sacrificing those developmental students who sorely lack the efficacy, time management, and self-discipline skills that are requisite under such a self-directed model of learning (Kohler, 2012). Evidenced by significantly negative completion rates, pass rates, and math anxiety scores, the emporium model of instruction is clearly not the silver bullet that developmental educators are searching for (Twigg, 2011); unless the intention of that bullet is to kill off the confidence, hope, and resilience of developmental math students. Proponents of emporium models claim that it is unjust to subject a diversified population of students, with varying styles of learning, to the same, tired, and played-out, lecture-based instruction (Stern, 2012); but in doing so, have now erred on the other side of this all-or-nothing extreme by eliminating lecture for the 79.6% of students who would actually prefer to see technology used in moderation or not at all (Caruso & Salaway, 2007).

Technology concurrent with traditional lecture. Though computer-assisted instruction can easily take students to a level of mastery learning never heretofore imagined, educators must be mindful of striking that perfect balance between classroom participation and digital isolation. Boylan (2005) gravely counseled that the implementation of technology will cause developmental students to either suffocate or snore, considering the extent to which it is used.

That is why Armington (2003), in a publication devoted to the best practices in developmental mathematics, hailed the use of technology, *concurrent with traditional lecture*, as a recipe for student success. For the hundreds of developmental programs continually mired in failure year after year, an adoption of computer-assisted teaching and learning offers a promising step in the right direction. With developmental students comprising a markedly diverse range of backgrounds, abilities, and educational levels, computer-assisted instruction provides the tools necessary for developing personalized understanding and a steepened locus of control attained from software learning exercises, while classroom teachers model positive behaviors and aptly instruct students on how to academically and affectively succeed in math.

The control group in the current study embraced this particular recipe by accompanying traditional lecture with computer-based homework to effectuate monumental gains over their strictly computer-based counterparts. Much like the emporium model students, participants in the control group were encouraged by their instructors to work and re-work computer-based assignments until 100% mastery, thereby benefitting from the instantaneous feedback and mastery learning pedagogies that the emporium model laid claim to. These computerized skill and drill gains are similar to what Duhon, House, and Stinnett (2012) found through a repeated measures ANOVA when deducing that math fact fluency scores attained through mastery-based computer exercises were not detectable in paper and pencil learners.

In response to one particular software-specific questionnaire (Canfield, 2001), students reported that they learned more with the assistance of the computer software and appreciated the instant feedback generated after both correct and incorrect responses. Another reported benefit of using the computer-assisted technology was the students' ability to work at their own pace in a stress- and anxiety-free format. To this end, Canfield viewed computer software programs as a good supplement to classroom instruction, but not a good enough means to replace a human teacher.

Teachers matter. A sizeable portion of the research literature trends along the same lines as Canfield (2001) in that computer-assisted instruction is best utilized when it serves in its namesake capacity of *assisting*, not replacing (Stillson & Alsup, 2003). Skeptical of overall effectiveness of computer-based instruction, Epper and Baker (2009) remarked that "emerging pedagogical themes suggested 'promising but unproven' instructional strategies" (p. 10). Having found no clear consensus pertaining to the effectiveness of technology-based instructional advancements, including CAI, Internet-based instruction, self-paced, distance learning, and the like, Epper and Baker were left to conclude that "technology should be a supplement to, as opposed to a replacement of, more traditional delivery methods" (p. 10). As frequent contributors to various journals of developmental education, Brothen and Wambach (2000) confirmed that the primary consideration that drives the implementation of educational technology is the magnitude of the software's role. While technology is noticeably enraptured in every detail of this generation's life, that is no justification for superseding the imperative role of a classroom teacher.

With both the control and treatment groups utilizing the same MathXL software in their developmental courses, it would seem to reason then, that the variable that is accountable for much of the statistical significance between groups is that oft-overlooked, imperative role of the classroom teacher. In the current study, the fact that nearly one-fourth (23%) of all emporium-model participants failed to even complete the course demonstrates the marginal impact that course instructors make on computer-based learners. Similarly, with only one-in-four emporium-model students successfully completing both pre- and post-surveys, it is within reason to deduce that emporium-model instructors are rendered impotent, with few opportunities to make meaningful relationships and connections with students.

Consequently, the one overarching theme that resonates throughout the research data and complementary literature is that the value of an in-class teacher should never be underestimated. Whether it is warmly mentoring and modeling the correct way to work through problems or deeply imbedding concepts into the students' minds through a memorable learning activity, the research concedes that teachers matter. Throughout the duration of the research study, casual interactions with emporium-model students revealed consistent feelings of estrangement, frustration, and helplessness as they attempted to navigate an entire math course with what they felt was very little guidance and support.

In a survey related to course effectiveness, students revealed that the professor's course structure (the pacing, grading, and implementation of the class as a whole) was the variable most-highly correlated with perceived course effectiveness. Interestingly, initial surveys revealed that computer-usage ranked last among variables attributed to course effectiveness (Tamim, Lowerison, Schmid, Bernard, & Abrami, 2011). Similarly, in a review of the literature linking evidence-based findings to successful developmental math pedagogy, Structured Student Collaboration was found to have the most profound impact on cultivating success in the developmental student; which is exactly what a marquee teacher facilitates and what the emporium model strays from (Hodara, 2011).

Bolstering the argument in favor of skilled classroom teachers, Hodges and Murphy (2009) examined four hypothesized sources of self-efficacy on mathematics students within an emporium-model course: enactive mastery experiences (previous successes in one's life), vicarious experiences (role model, *or teacher*, performing a task successfully), social persuasion (encouraging feedback), and physiological state (finding a comfortable level of stress and emotion). A regression analysis found that the experiences that most reinforce the self-efficacy of asynchronous, emporium-model math learners are vicarious experiences, followed by affective/physiological influences.

Developmental math students are high-risk students. They are fragile. They need guidance and support. They possess apprehensions about mathematics that cannot be eradicated by video tutorials and informal computer labs. They cling to doubts about their mathematical self-efficacy that lead to avoidant coping strategies such as withdrawal. It is clear from this current research study that, for developmental math students, required e-text readings and videos cannot reverse years and years of bad academic habits. "Teachers model positive behaviors and change aversive attitudes; computers do not" (Kohler, 2012, p. 33).

Teachers as solutions to math anxiety. Teachers play a critical role in reducing math anxiety and encouraging students to pursue challenging courses. Rameau and Louime (2007) found that one of the most efficient ways to spike students' interest in mathematics is to expose them to teachers who are passionate about the subject. Teachers, especially developmental educators, should be aware that their students may suffer from math anxiety. As a result, instructors should employ effective teaching methods that are tailored to individual students' needs and aimed at lessening math anxiety in the classroom.

Making the classroom an emotionally secure environment will positively affect how students learn, think, and remember. Recalling Smilkstein's (2003) research, students who feel emotionally threatened or academically insecure will have their brains negatively impaired by "flight" hormones. Similarly, students who report feelings of respect and safety are more motivated and successful in the classroom, leading Smilkstein to conclude that "emotions and thinking, learning, and remembering are inextricably bound together" (p. 86).

Those interviewed in Shields' (2007) study expressed a need for teachers who care about students as well as their math education. From the litany of research, it is apparent that "students often learn more from math teachers' attitudes than from their aptitudes" (p. 55). If math instruction is to be effective, it must start with teachers who portray positive, confident attitudes about the subject. As students traverse the developmental education sequence, their success in subsequent college-level courses is invariably linked to the emotional and supportive presence of a full-time instructor (Moss, Kelcey, & Showers, 2014).

The idea that a positive learning environment elicits positive student performance is of no surprise to researcher, Ken Bain. In his nationwide search for the best college professors, Bain (2004) found that the upper echelons of collegiate professors consistently engage their students in mutual feelings of respect, openness, and trust. The best teachers are able to capture their students' attention and loyalties by using what Bain refers to as "warm language" (p. 122). Warm language describes, invites, and tells a story with the intent of drawing listeners in.

Unfortunately, the highly-structured, algorithmically-centered nature of math oftentimes seduces math teachers to fall into an emotionless rut characterized by cool-language lecturing. A potential solution to warming frost-bitten math teachers - one that imbues a compromise of lecture and technology - is to provide online discussion boards in which prospective teachers encourage one another to overcome their fears related to teaching mathematics (Liu, 2008). Liu investigated the impact of online discussion of Anxiety towards Teaching Mathematics (ATTM) on elementary teacher candidates' self-reported ATTM. It was found that online discussion of ATTM significantly reduced participants' anxiety of teaching mathematics after a period of weeks. Many teachers began to embrace mathematical concepts and engage students in warm-language explanations. Consequently, Liu recommended that online discussion of ATTM be established as a primary component in methods courses for elementary teacher candidates. Similarly, Van Gundy, Morton, Liu, and Kline (2006) found that class anxiety levels dropped and self-esteem enhanced as a result of digital class-discussion boards, while students' internal locus of control had no significant change.

Though students are ultimately the ones responsible for their own educational effort and persistence, a good teacher can go a long way in affecting students, especially at-risk students within the population of developmental learners. While it is true that students should be familiar with the developmental math curriculum, having already been exposed to it through their high school education, most students who place into developmental math have not truly cared to learn the material until it is presented to them in higher education – when it is their money on the line and their long-term future at stake. Leaving such a pivotal learning experience to a computer program is a wasted opportunity for the thousands of developmental students who have come to college ready to rectify the educational mistakes of their youth and be shown how to finally do the math. The research data have made it explicitly clear: the one equation that most developmental math students can agree upon is Teacher + Technology = Success.

Buffet model. Upon analyzing the negative course completion data of developmental math students, Fike and Fike (2012) suggested the need to design developmental math courses that target and meet the needs of specific student profiles instead of a one-size-fits-all approach. “While technology-based delivery methods may not be statistically proven to support improved learning outcomes, it very well may be that student persistence in developmental math is enhanced by having multiple options for delivery” (Epper & Baker, 2009, p. 13). Believing that affective factors such as anxiety and locus of control influence academic outcomes just as much as competence, Fike and Fike embraced the idea of doing away with traditional competency-based placement exams and replacing them with a more complete diagnostic tool that takes into account students’ affective, emotional, and intellectual life situation. Not only would such a diagnostic place students into the correct mathematical course, but it would also recommend the means of instruction by which the course would be taught.

This potential balancing of high-tech versus high-touch is what NCAT (2011) terms a “buffet plan,” in which instructional delivery is customized according to student preference, background, and skill set. Aptly applying the buffet analogy into the academic setting, Miller (2010) posited that even the most delectable barbecue in the world would never please a vegetarian, thereby accentuating the need for institutions to diversify their course offerings to include lecture, emporium, and hybrid sections, among other modalities of instruction. At the fundamental core of the buffet model is the dual mission of customizing student placement into the appropriate course, and taught by the appropriate method. In terms of instructional delivery, while most institutions have chosen to put all of their eggs in one collective basket, the buffet model gives high aptitude and self-directed developmental students the option of registering for a self-paced computerized course, while those in need of more personal accommodations can register for lecture-style offerings – which could even be supplemented with computer-based homework for more of a hybrid feel – depending on student preference (Kohler, 2012).

Though relatively unexplored within the body of research literature, Miller (2010) has reported on some initial buffet findings coming out of Ohio State University's introductory statistics course. Prior to registration, students took a questionnaire to first determine their preferred learning styles. Students were then placed in the appropriate instructional model that corresponded to their survey results. As a result, dropouts, withdrawals, and failures dropped from19% to 12%.

As illustrated by the emerging success of Ohio State's introductory statistics course (Miller 2010), the key in determining the most suitable means of instruction for individual students lies within the intense amount of counseling, diagnostics, and advisement that is necessary before establishing each student's "best fit" means of instruction. Though student preference should be taken into account in determining the type of instructional delivery, it should not be the sole measure by which course sections are chosen. Roblyer (1999) expressed great concern over the reasons students use in choosing between virtual and traditional environments of learning. Principally, Zavarella and Ignash (2009) found that many developmental students who possessed poor time-management skills chose technological teaching over lecture learning due to the widespread misperception that "online is easier." As a result of students self-selecting their modality of instruction, Zavarella and Ignash reported significantly higher withdrawal rates among those computer-based learners who quickly found out that the same amount of work was required between the digitized class and the lecture-based class.

In determining which types of students fare better in a traditional lecture environment, Kinney (2001a) found that students who enroll in lecture classes prefer to learn by watching and listening to an instructor present material while still being able to ask questions during the instructor's presentation. These students value human interaction. Students who prefer lecture-based courses also expressed that they frequently benefited from other students' questions and the privilege of listening in on the instructor's response. Kinney concluded that students who prefer lecture courses consider classroom interaction an invaluable experience that provides them with more personalized attention than a computer-mediated course would.

On the technological side of the discussion, Kinney (2001a) determined that students who enroll in computer-mediated courses find multimedia's interactivity and immediate feedback to be rather captivating. With technological simulations and diagrams to draw them in, these students prefer multimedia's visual presentation over what instructors can typically write on a board. Kinney also found that students who have a proclivity toward computerized learning prefer to learn independently - in a setting that allows them to control the pace of instruction - rather than having another person show them everything.

Whereas one-size-fits-all emporium and lecture models are decidedly one-sided in appealing to student preferences and customs, the buffet model makes it possible for developmental educators to take advantage of computer-based instruction as well as traditional classroom instruction without alienating those developmental students who possess strong inclinations as to how they prefer to learn. By taking into account the multi-faceted construct of student learning, developmental educators should use diagnostic tools to assess students' emotional, psychological, and intellectual standing before placing them in an appropriate instructional design. Through a buffet model of student learning, it becomes possible for developmental learners to have their cake and eat it too.

Implications

Where the current research study excels is in its specificity and applicability to the area of developmental mathematics - with the study's focus on how developmental student learning differs from students enrolled in college-level math courses. Acknowledging that there is a real and fundamental difference in how these high-risk developmental students learn, the current study focused on finding the best fit for an under-researched population of learners. As such, the results of this research study are not intended to be transferable among other populations of learners such as college-level, secondary students, or elementary school learners; but are to be used as a guide in furthering the discussion of how developmental students learn best.

The implications drawn from the research data suggest that the course selection process should be improved for developmental students. The emporium model was implemented out of concern that "not everyone learns the same way," but in doing so, backed students into the very same corner by making everyone learn from the wisdom of a computer. As such, there needs to be a better and more accommodating course selection process to match students' ideal learning modality to an appropriate means of instruction. The use of questionnaires, surveys, and aptitude pre-tests should be used in determining which developmental students are capable of working on computers at their own self-paced freedom, and which ones are not.

The results of this study have already acted as an impetus for change within the treatment group's emporium model. After surveying the emporium's sluggish completion and pass rates, the department recently elected to adopt a second pathway of study known as a flipped classroom. Instead of working independently at a self-determined pace (as in the emporium model), this second modality of learning requires students to watch the videos and read the e-text ahead of time, then meet in class four times a week to work on the computers and receive a small lesson from an instructor on the day's topic. According to Twigg (2011), the failure of any emporium model is predicated by a system that leaves students on their own doing computer homework in an unstructured, open-entry/open-exit model. In order to succeed, students need sufficient structure within a well-articulated set of requirements that the flipped classroom intends to provide.

As the treatment institution continues to tweak, refine, and redefine its pervasive presence of technology, Jacobsen (2015) believes that positive changes can only come about as long as institutions are willing to look inward at what they are doing to impose artificial and unnecessary barriers for developmental students. Emporium-model faculty meetings that discuss policy more than pedagogy are in danger of over-burdening students with minutiae over math. Limiting when and where students take placement tests; requiring certain standards of note-taking; limiting the number of re-tests within a certain period of time; requiring mastery-level understanding of hard, exception-to-the-rule problems; and limiting the length of student-teacher interactions in the computer lab were all noticeable barriers within the researched emporium model that played a part in impeding students' progress. As such, the key to unlocking developmental math success begins with reducing unnecessary cognitive and logistical burdens (Epper & Baker, 2009).

Considering how the teacher-led lecture group out-performed the emporium model in terms of completion rates, pass rates, and anxiety reduction, it is important to note that lecture does not infer old-fashioned. In lieu of dryly pontificating facts and algorithms, the lecture-based instructors infused a nice balance of teaching, structured activities, group work, and MyMathLab computer software homework assignments. To this end, the current research merits the implication that teaching and technology can work together hand-in-hand. Instructors should not avoid - simply for the sake of tradition - the positive benefits of computer-assisted learning that include immediate feedback, diverse learning, and concept mastery.

On the other hand, the current research data also demonstrate just how precarious extreme-dependence on computerized learning can be. According to Saeed, Yang, and Sinnappan (2009), “a major obstacle in the practice of web-based instruction is the limited understanding of learners' characteristics and perceptions about technology use” (p. 98). With statistically better completion rates, pass rates, and anxiety levels, the control group provided a significant glimpse into the preference and practicality of mixed-methods course sections that feature quality teachers coupled with computerized feedback.

The data in favor of the teacher-led lecture group also imply that the role of the teacher matters more than just the presence of a teacher. Both groups of participants had built-in access and numerous opportunities to work with their teachers, but the role in which those instructors were cast varied dramatically. With completion rates that were nearly five times higher than the emporium model, the students made it abundantly clear which defined role they prefer their instructors to play.

Not only does the functionality of a teacher matter for developmental students, but the type of teacher is just as important. Many developmental courses are taught by high school teachers moonlighting as adjuncts, or by tenured mathematics faculty with PhDs in mathematical theory. Neither is generally well-versed in how to deal with the distinct stresses and demands of their developmental students. As such, more and more universities are offering graduate degrees specifically in the field of developmental education (Smilkstein, 2003). To this end, the current research suggests the importance of finding faculty who have a desire to work in the field of developmental mathematics and possess the wherewithal in knowing how to accommodate the unique learning needs of the population of developmental learners.

Limitations

Though the findings of this study help in drawing conclusive arguments regarding teaching and learning, one of the pertinent limitations to the study was its restrictive inability to generalize the study's significant results beyond the sample's intended population. With its primary contributions made relevant in the field of developmental education, it is unlikely that this study's results are able to transfer to different populations such as secondary school students or college students who are no longer in need of remediation.

Inherent within a quasi-experimental design is a built-in weakness attributed to a lack of randomization. Unlike a true experimental design, the current research was limited in that it sought to avoid the unethical practice of randomly selecting students to attend particular institutions and participate in one modality of learning over another. Participants freely selected which school to attend, which instructors to sign up for, and voluntarily agreed to take part in the research study.

Not only was participant recruitment non-randomized, but the self-selected sample was limited to only those students taking a class from the instructors who volunteered to make their course sections available for the study. Among the pool of faculty volunteers, more than three-quarters of participating instructors at both institutions were adjunct faculty, as opposed to full-time contract faculty, making it difficult to discern what is truly happening among the faculty who carry a majority of the workload. Such dependence on adjunct faculty could have possibly skewed the results in the event that adjunct instructors persuaded, either implicitly or explicitly, their students to answer survey questions a particular way, in the hope that this data would be viewed in a positive light and shared with the department chair or other managing supervisor. The research data was also subjected to a potential compensatory John Henry effect (Gall et al, 2007) given that the two institutions knew their data would be compared against a “rival” institution. Despite the potential sampling bias that is inherent with any quasi-experimental design, the relatively large sample size of 775 total participants helped establish validity that the convenience-sampling of participants was indeed representative of the population of developmental learners as a whole.

In full disclosure of potential biases, it should be noted that the principle investigator in this study is a former emporium-model instructor. Having grown dissatisfied with falling pass rates and rising student dissatisfaction within the emporium model, the principle researcher left his teaching position at the treatment-group university at the beginning of the dissertation process. In assembling a dissertation committee, the principle researcher opted to include and work closely with a faculty member from the non-emporium control group, while balancing the discussion by also including an instructor at another institution who has been involved in the emporium-model conversion at her university. Further, in an effort to recuse himself from any blatant bias against the emporium model, the principle researcher removed himself from any classroom interactions with potential participants, communicated professionally to faculty via email, and provided boiler-plate scripts for teachers to use in the recruitment of participants.

Methodologically, the research procedures were carried out in exactly the same manner, while surveys were scored identically at both institutions. In light of any potential bias stemming from the principle researcher, the data ultimately speaks for itself against the effectiveness of the emporium model for developmental math students.

Concerning the definition, measurement, and validity of the research variables, the lack of standardization between treatment and control groups served as the most severe limiting-factor in terms of data interpretation. Though tasked with teaching the same curriculum content, the course procedures, grading scales, and assessments varied widely from class to class (See Appendix E for emporium-design course syllabus). While the emporium model followed a rigid structure of grading, attendance policies, and assessment procedures that were standardized across all courses throughout the university, the courses within the lecture-based control group were left up to individual interpretation, with each teacher freely creating their own assessments and point-distribution policies. In teaching the same content, the lecture-based group appeared to focus more on teaching the fundamental core curriculum, while the emporium model assessed more "exceptions to the rule" and inherently difficult story problems.

Without question, the hardest part in comparing two seemingly similar, yet distinctively different programs was in determining which variables were functionally possible to research and which variables depended on a more standardized experimental design. With a lecture-based group featuring partial-credit bearing multiple-choice assessments and an emporium model that required students to flawlessly type in correct responses - yet provided students with an unlimited number of attempts to pass an assessment - the three academic variables of completion rate, pass rate, and retention rate were chosen over variables such as standardized post-test exams, student grade point average, or any other number of variables that would have been sorely affected by a lack of standardization.

This lack of course standardization produced an external threat to validity that was magnified by overwhelmingly significant completion rate and pass rate data skewed in favor of an arguably “easier” lecture-based course. By offering multiple choice tests that include partial credit for incorrect solutions, the lecture-based group has inherently built up a program that is more favorable toward student success (as artificial as that success may be) than the rigid, quest for perfection that the emporium model emphasizes. To this end, Zhu and Polianskaia (2007) argued that higher pass rates in lecture courses could be a result of teacher inflation and sympathetic grading tendencies that do not exist in computer-mediated formats.

As for the affective variables of math anxiety and locus of control, the poor survey return rate among emporium model participants was particularly concerning, although it seemed to exemplify the lackluster attitudes and mounting frustrations of those students who failed to complete both pre- and post-surveys as a result of their lack of attendance. Among those students who successfully completed both rounds of surveys, it was remarkable to note the consistency of responses among individual classes. As the anxiety-apprehension surveys were being scored, the reported levels of anxiety seemed to vary dramatically from teacher to teacher. Though this phenomenon was not statistically verified teacher by teacher, it is worth speculating whether teachers were coaxing students into certain answers, or – according to the most likely source of the perceived variance – teachers truly do possess the inimitable effect of causing, or relieving, mathematical-related anxieties (Bain, 2004; Shields, 2007).

In terms of instrumentation, the locus of control survey was the biggest liability against validity and reliability. Though Zerega et al. (1976) were able to demonstrate the survey’s test-retest reliability and concurrent validity, the actual implementation of the survey in a strictly educational environment produced little variability and a lot of confusion among respondents in the current research study. In the survey, participants were asked to choose between two dichotomous statements that they felt best-described their point of view. Unfortunately, many students created new options such as “both” or “neither” that thereby disqualified their surveys from the study. As a whole, the survey asked too many generalized questions that possessed a more political timbre than an educational purpose. In a deeply conservative state, it was not surprising that the outcomes between the two groups were nearly identical - given that most students interpreted the survey politically rather than putting the statements into more of an educational context. For the purpose of the current research study, the locus of control survey could have benefitted from more education-specific questioning and scenarios as opposed to general world attitudes.

Lastly, a repeated measures ANOVA was selected for the data analysis involving each of the pre-post surveys. In selecting a repeated measures ANOVA, the results become narrowly limited in their interpretation to a single group (Howell, 2008). Therefore, data analysis of the affective surveys did not initially look for differences between treatment and control groups, but instead, investigated within-group improvements over the course of the semester. In the context of the current research study, a significant F-value for the lecture-based control group coupled with an insignificant F-value for the emporium-model treatment group does not imply that control-group scores are better than the treatment; rather, it simply states that participants in the control group reported significantly lower levels of anxiety as the semester progressed that were not evident in the treatment group. Once a significant F-value was identified, a subsequent t-test was used to determine if the post-test scores between groups significantly differed, given that the pre-test means were virtually identical to begin with. Had the affective research hypotheses sought for survey differences between groups, an analytical alternative would have been to use ANCOVA from the outset, which would have controlled for initial differences between the groups.

Recommendations for Future Research

On the heels of the current research study, it would be prudent to carry out a replication study between the exact same institutions within the next year or two. With the emporium model still in its infancy, many students were likely grappling with and resenting the change away from a traditional manner of learning that they were greatly accustomed to. In a few years, once the emporium model has had a chance to establish itself, perhaps students will develop brighter attitudes and become better acclimated to the way in which the emporium model operates, thereby improving upon the results presented in this study.

In carrying out the replication study, a single adjustment would be in finding an alternative instrument to measure locus of control. The use of Rotter's internal-external scale muddied the possible effects of self-efficacy and attribution, and as such, needs to be re-examined. An education-specific instrument would be of better use in determining whether or not the self-paced emporium model of learning helps students take more ownership over their educational outcomes.

In response to the tremendous lack of standardization among courses in the current study, future research should strive to measure content acquisition and knowledge in the form of a standardized pre- and post-test. The completion and pass rate data from the current study was a solid introductory look into the emporium model that can only be enhanced through a true apples-to-apples comparison of future research. Pre-posttest standardization would help discern whether or not student pass rates are truly a function of student knowledge or teacher inflation.

Though not statistically controlled for in the purpose of the current study, the prevalence of female mathematics anxiety was hard to ignore. According to existing literature, when it comes to dealing with mathematical tasks, 62% of women become anxious around numbers compared to 47% of men (Thilmany, 2009). Women's propensity toward math anxiety has resulted from a combination of self-perpetuating cultural and gender stereotypes. Being good at math is consistently interpreted as acting unfeminine; while the masculinity of math is evidenced from early childhood as young boys are more likely to be given blocks or other building toys to play with. Likewise, boys' affinity toward sports helps them better understand how objects move in time and space (Ruffins, 2007). In the classroom, boys are subconsciously encouraged to take more risks than girls and are more likely to have their mistakes tolerated by male and female teachers alike. With a lack of female role models in math and science, girls begin acting out self-defeating behaviors to draw themselves away from mathematics. If confronted with the difficulty of math, boys feel as if they have to stick with it, while girls are more likely to escape math courses as early as the tenth grade. Consequently, future research is needed in identifying potential methods for reducing mathematical apprehensions and insecurities among female developmental math students.

While emporium-model advocates speak against the travesty of tired and trodden lecture halls, the advocates for quality lecturers decry the enveloping dependence on computer-based instruction. Though in discord, the two opposing arguments actually voice the same refrain: one size simply does not fit all. One method of instruction cannot possibly meet the needs of a population as diverse as the demographic of developmental learners. To this end, further research needs to be directed toward the buffet model of instruction in which student characteristics are evaluated and assessed before determining which instructional modality best meets their individual needs. In accordance with the buffet model, further research is needed in identifying valid and reliable instruments that can accurately assess students' affective traits such as anxiety, self-efficacy, time management, locus of control, and learning style preference that have the ability to effectuate student success just as much as the long-standing use of intellectually-based placement tests.

Embedded within the lecture-based group's statistically significant results is the impactful influence of a quality teacher. Overwhelmingly, the group whose teachers were given liberal freedoms and prominent roles in educating their students were able to produce higher completion rates, pass rates, and significantly minimize mathematical apprehensions. Unfortunately, the current research did little to establish whether these gains were warranted, or if they were artificially enhanced within the construct of an inherently "easier" program. To examine this concern, it is recommended that all future developmental math studies explore the students' ultimate confirmatory measure of triumph: successful completion of a college-level math course. If developmental math programs are demonstrating prestigious results, yet passing along under-prepared students to college-level professors, then these programs are simply in existence for their own sake, and not for the essential mission of college-level completion. As such, no research within developmental mathematics should be classified as a detriment or a champion without first analyzing its effect on student success in subsequent college-level math courses.

Of course, in order to move developmental students through the remedial track in a timely manner, the issue of retention becomes a particular concern. The current research data showed no significant difference in drop-out rates among emporium and lecture-based learners, with 20% of participants failing to re-enroll in school the following semester, and another 20% projected to leave before the start of the next school year (Jacobsen, 2015). While the prominent role of the instructor helped magnify the significant completion and pass rate data, teachers could not encourage their students to return to school any more than a computer software program.

In an attempt to shed new light on the elusive question, "who are the best teachers and what do they do that sets them apart?" perhaps the definitive mark of teacher effectiveness lies within the variable of student retention. In sorting through this study's retention data, invariably, students who did not return to school did not pass their math class the previous semester. Because this conjecture was gathered through simple pattern detection and not numerical analysis, it is recommended that future research attempt to first establish a correlation between failure to enroll in school, or in a math class, and the previous semester's math grade. If student attrition is assumed to be associated with mathematical failure (Jacobsen, 2014), then presumably, the best teachers are the ones who are reversing typical developmental-learner avoidant behaviors, and keeping students re-enrolled on the developmental track. Essentially, there is one statistic that very few teachers, if any, tabulate when analyzing their teaching effectiveness each semester. While completion rates, pass rates, final exam scores, student evaluations, and class grade point averages are typical fodder for deducing teacher greatness, it is recommended that teachers measure their true effectiveness by calculating the percentage of returning students who failed the same instructor's course the semester before. Completion rates and student evaluations can be more a measure of popularity, while pass rates and final exam scores can be inflated at the instructor's discretion. Whereas most failing students blame external attributes such as the teacher or the hard tests on their way to dropping out, those failing students who choose to re-enroll with the same teacher demonstrate a stunning level of trust and confidence in that instructor's ability to teach developmental mathematics. Therefore, it would be fascinating to study teachers' ability to retain their own failed students as a possible indicator in the multi-variable task of identifying quality teacher effectiveness.

Lastly, a longitudinal study measuring mathematical content knowledge between emporium and lecture-based groups would be of great interest. Building off of the foundational memory theories of Conway and Gathercole (1987), it would be of practical importance to determine which modality of mathematical instruction leads to greater long-term retention of mathematical concepts and problem solving. Nearly three decades ago, Conway and Gathercole presented subjects with informational material in a variety of modalities ranging from reading silently, to silent reading with mouthing, to reading and hearing. Similarly, the current research study presented participants with mathematical information in a myriad of human-centric and computer-based modalities. Ultimately, Conway and Gathercole found that acoustic learning was associated with higher long-term memory and recall than silent learning, while the impact of technological learning on long-term memory remained to be seen. The repetitive, mastery-based pedagogy of the emporium model has the potential to secure a spot in students' long-term memories; however, the silent, independent nature of computerized learning could likewise subject students to a compromised long-term memory. On the other hand, students in the lecture-based group sacrifice the benefit of repeated mastery learning in favor of the prospect of experiencing deeply imbedded and visceral learning opportunities from an evocative instructor. If, after all, the mission behind developmental education is to prepare students to advance through collegiate-level mathematics, it would be of great interest to see which model of instruction - the emporium or the lecture - better retains and assimilates long-term mathematical understanding, evidenced by students' standardized final exam scores taken two, three, or even five years after first completing the course.

Conclusion

Because the greatest benefits of computers do not initially appear to compatibly conform to the traditional lecture-based instructional style within higher education, many instructors are reluctant to accept the notion that technological appeal can draw students in while making learning a varied and enjoyable process. As instructors learn to shed their fears and accept what technology does well, they can begin envisioning a blissful pedagogical marriage between the best that the human classroom experience has to offer, intertwined with the customization and appeal of computer-assisted instruction.

Figuratively speaking, asking developmental students to take the reins of their own mathematical learning within a technologically-based emporium model is akin to a parable about a loving father helping his young son develop a sense of confident independence by asking the boy to get himself ready for bed. When the young son returns several minutes later, the father notices that the boy has yet to change into pajamas or brush his teeth. Incredulous, the father exclaims that he is certain, having seen his son do it many times before, that the boy should know how to get dressed and brush his teeth. Expressing his disappointment, that father sends the boy away. Again, the boy returns, having made no discernible attempt to do as his father had asked. The father lectures his son about the importance of learning by doing and how it will embolden his son's confidence and character. He turns the boy away one final time, with the intent of watching his son carry out this seemingly simple task through to the finish. As the father spies on his son's progress, he becomes enraged as he watches his son pace around his bedroom, almost as if he were blatantly avoiding his father's instructions. The father vehemently expresses his displeasure and demands to know why his son simply refuses to get into his pajamas and brush his teeth. "I want to, Dad. I tried, but I am not tall enough to reach my pajamas out of the top drawer and I am not strong enough to twist the cap off of the toothpaste."

It is not that developmental students in an emporium model are trying to be delinquent or trying to fail. Though the data from this research study revealed that one-fourth of the sampled emporium students dropped out before the end of the semester - and another fourth did not pass - it was not due to their lack of desire. Just as the father questioned his son's motives and desire, many instructors within the emporium model are quick to chastise and blame students for not taking a more proactive approach to their studies. Instead of placing blame and dwelling on what students should be doing, it would be best for programs to look inward and question the effectiveness and pedagogical soundness of an emporium model of instruction on developmental math students. With heightened emotions of math apprehension and low feelings of self-efficacy, developmental math students are not yet tall enough to reach the drawer, nor are they strong enough to twist the cap off of the toothpaste. Classroom teachers are needed to model the appropriate way to solve problems and develop algorithms. Classroom teachers are needed to motivate, support, and encourage a population of self-conscious students. As tuition rates continue to climb and student debt reaches unprecedented levels (Jacobsen, 2014), the least that institutions can do for their students is to provide them with a memorable educational experience; not through the fleeting, compulsory readings of an e-text, but through the visceral, teachable moments that can only come to pass at the hands of expert an instructor.

Ultimately, Bennett (2001) conceded that, despite the sheer manpower of a single computer, human instructors are vital components of the teaching and learning process. While few would question a computer's ability to simulate, replicate, and carry out personalized tutorials, the wonders of artificial intelligence are still unable to mimic the true conveyer of truth: the Holy Spirit. “But the Comforter, which is the Holy Ghost, whom the Father will send in my name, he shall teach you all things, and bring all things to your remembrance, whatsoever I have said unto you” (John 14:26). Human teachers are absolutely necessary for facilitating and enhancing ideas, expounding on student questions, formulating discussion groups, and preparing interest-centered workshops and seminars (Mark 4:2). After all, it was of the Savior – a teacher – that the unequivocal testimony of human learning was uttered: “And they said one to another, Did not our heart burn within us, while he talked with us by the way…?” (Luke 24:32). In its truest form, the word education comes from a Latin derivative meaning “to lead out.” As such, any implementation of computer-assisted instruction must consider an instructor’s ability to teach with the Holy Spirit. From a biblical worldview, teachers will be an integral component of future educational technologies, forever intertwined with the human aspects of education by personally connecting with the hearts of every learner.

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APPENDIX A

Participant Consent Form

You are invited to be in a research study of student academic outcomes and beliefs about computer-based mathematics instruction. You were selected as a possible participant because you are registered for a developmental math course this academic semester. I ask that you read this form and ask any questions you may have before agreeing to be in the study. Participants must be 18 years of age or older to participate in the research study.

Background Information:

The purpose of this study is to identify the effectiveness of computer-based mathematics instruction on developmental math students, in comparison to traditional lecture-based developmental mathematics instruction. For the purpose of this study, effectiveness will be measured according to student pass, completion, and retention rates. Additionally, two psychological measures of effectiveness will be surveyed in regards to perceived mathematics anxiety and student ownership/control over their learning.

Procedures:

If you agree to be in this study, I would ask you to do the following things: All developmental math students will be given a beginning-of-the-semester and end-of-the-semester survey pertaining to mathematics anxiety and their perceptions toward academic success and failure, which should take no more than 20 minutes of your time to complete. At the conclusion of the semester, I will use either your name or the student ID number that you provided on your surveys and work in conjunction with your school's data collectors to access your final grade for the course and your enrollment status for the following semester.

Risks and Benefits of being in the Study:

Participation in this research study does not appear to involve any added risks or discomforts. The only foreseeable risks would be associated with student frustration concerning their instructional delivery or the accidental loss of confidentiality. However, procedures have been identified and put into place to secure the data and your confidentiality. Similarly, the potential risk of minor grief and frustration is no more than you would encounter in any other academic setting.

There may not be any direct benefits to you from these procedures. The investigator, however, may learn more about the effectiveness of computer-based instruction on the population of developmental math students, and the factors that lead to effectiveness. An effective model of instructional delivery may be scaled up so that developmental students across the state, or nation, can benefit from what is learned.

Compensation:

Students who participate in this research project will not be compensated. No form of monetary payment or extra credit in the course will be offered to those who agree to participate. Similarly, those students who refuse to participate will not be subjected to harassment, pressures, or ill-feelings from their teachers for non-participation.

Confidentiality:

The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify subjects. Research records will be stored securely and only researchers will have access to the records.

Participants will be identified by a school-issued student identification number. Collected data, both hard copy and digital, will be stored in a locked filing cabinet in a locked room throughout the duration of the study. Following completion of the study, personal, identifiable information will be kept for a three-year period, after which the investigator will destroy the information collected as part of this study.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with your university. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

Statement of Consent:

I have read and understood the above information. I have asked questions and have received answers. I consent to participate in the study.

Signature:____ Date: ___________________

Signature of Investigator:____________________________ Date: ___________________

APPENDIX B

IRB Approval Letters

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

August 22, 2014

IRB Approval 1377.082214: Academic and Affective Outcomes of Computer-Based Instruction on Developmental Math Students

We are pleased to inform you that your above study has been approved by the Liberty IRB. This approval is extended to you for one year from the date provided above with your protocol number. If data collection proceeds past one year, or if you make changes in the methodology as it pertains to human subjects, you must submit an appropriate update form to the IRB. The forms for these cases were attached to your approval email.

Please retain this letter for your records. Also, if you are conducting research as part of the requirements for a master's thesis or doctoral dissertation, this approval letter should be included as an appendix to your completed thesis or dissertation.

Thank you for your cooperation with the IRB, and we wish you well with your research project.

Sincerely,

LIBERTY
UNIVERSITY.

Liberty University | Training Champions for Christ since 1971

May 1, 2014

You submitted for Institutional Review Board review a human subject research proposal entitled, “Academic and Affective Outcomes of Computer-Based Instruction on Developmental Math Students.” Your study has been assigned the following IRB tracking number: #00942.

Based on the information provided by you, your research proposal appears to pose “negligible” risks to human subjects and, therefore, meets the Federal criteria for an “exempt” review.

UVU accepts Weber State University’s IRB review of your proposed study. You herein have approval from UVU's IRB to begin your research. This approval is effective until April 30, 2015. Continued approval is conditional upon your compliance with the following:

No other informed consent may be used other than that approved by the IRB on May 1, 2014.

All protocol amendments and changes to approved research must be submitted to the IRB and not be implemented until approved by the IRB. Please notify us of any changes made in the instruments, consent form, or research process, so the IRB can review and approve them before the change is implemented.

To ensure that individuals and organizations involved in your study are aware that you have received IRB approval, please use the IRB tracking numbers above on all documents and communications associated with this project as identification of IRB authorization (i.e., IRB Approval #00942).

When you have completed your research, please notify the IRB. In keeping with Federal regulations, you must retain non-identifiable research data for a period of 3 years from the date of completion of the research.

If you have any questions, please let us know. We wish you well with your research!

WEBER STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD (IRB)

March 5, 2014

Your project entitled "Cognitive and Affective Outcomes of Computer-Based Instruction on Developmental Math Students" has been reviewed and is approved as written. The project was reviewed as "exempt" because it comprises using curriculum and assessments, which would normally be used.

Subjects are considered adults and may choose not to participate. Signatures are required for participation. Notification of the study and how data will be reported are appropriate. No individual subject data will be revealed. All subject information will be confidential. Please seek approval from the mathematics department.

Anonymity and confidentiality are addressed appropriately, and the type of information gathered could not "reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation" (Code of Federal Regulations 45 CFR 46, Subpart D.)

You may proceed at this time.

Please remember that any anticipated changes to the project and approved procedures must be submitted to the IRB prior to implementation. Any unanticipated problems that arise during any stage of the project require a written report to the IRB and possible suspension of the project.

A final copy of your application will remain on file with the IRB records.

Chair, Institutional Review Board, Education Subcommittee

INSTITUTIONAL REVIEW BOARD
WEBER STATE UNIVERSITY | 1027 UNIVERSITY CIRCLE | OGDEN UI 84408-1027

APPENDIX C

Participant Recruitment Script

"One of the primary responsibilities of a mathematics teacher is to make sure that the instructional delivery and teaching methods in this course are conducive to learning, understanding, and mastering mathematics. While grades are the most common way that we define success in a math class, we have a unique opportunity this semester to assess whether or not our school's instructional delivery helps you, the student, feel more at ease with mathematics and more empowered to excel in this course.

To help gather this information, all of you in this class are invited to participate in a research study regarding the effectiveness of different instructional delivery methods. If you agree to take part in this study you will be asked to complete two short surveys pertaining to mathematics anxiety and your perceptions of academic success and failure.

Surveys will be completed at two separate points in the semester: during this first week of class and again at the conclusion of the semester. At the end of the semester, your survey scores, as well as your semester math grade, will be compared against students at a similar university who are receiving an alternate method of mathematics instruction.

I will pass out the two surveys today and ask that you consider being a part of this particular aspect of the data collection. Please return your signed consent form and all completed surveys to me either by the end of class today or the next time we meet. We hope that your responses will help us in determining whether or not our methods of instruction are meeting the needs of our students, so your participation in this study would be greatly appreciated.

Are there any questions or issues that I can help clarify? To gain a full perspective as to what this research project entails, I highly encourage you to read through the Letter of Informed Consent or ask me any questions that you may have to resolve whatever concerns you may have before answering the survey questions.

Remember, participation in this study is completely voluntary. You may refuse to participate or withdraw at any time without consequence. Your decision whether or not to participate will not affect your current or future relations with me as your instructor, or with the university. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships."

APPENDIX D

Faculty Recruitment Training Script

"As far as the actual distribution and collection of surveys will go, all of the survey materials will already be photocopied, stapled, and waiting for you in your individual classrooms. I would ask that each teacher follow a standardized method of student recruitment, which is why I have included a boiler-plate type script for you to follow as you pass out the survey materials to your students. You may modify the language to your tastes, but please refrain from interjecting any personal biases or opinions since the outcomes of your means of instruction will be compared against another school's survey and grade outcomes. I would ask that you kindly encourage their participation, but not in a way that comes across as mandatory.

Please allow students the opportunity to ask questions or voice any concerns that they may have regarding their participation in this study or the confidentiality of their responses. You may refer them to the Letter of Informed Consent for further clarification or contact information.

You may elect to give your students time right there during class, or ask that they complete the surveys on their own time outside of class. Please collect the surveys and included consent form in a timely manner, with a preferable cut-off deadline during that first week of classes. Since the surveys are designed as 'pre-test measures,' we do not want surveys coming in four to five weeks into the semester. Once you have collected the completed surveys, please return them to your department chair.

APPENDIX E

Emporium Design Syllabus

Course Description

Math 0950/0990/1010 is a developmental mathematics course (non-credited) designed to prepare students for Math 0990/1010/1050.

Prerequisite: Appropriate Accuplacer score.

Any student requiring accommodations or services due to a disability must contact Services for Students with Disabilities (SSD) in room 181 of the Student Services Center, 801-626-6413. SSD can arrange to provide course materials, including this syllabus, in alternate formats if necessary.

Adequate Progress

Students who have placed into developmental math (Math 0950, 0990, or 1010) must enroll in their first developmental course by their second semester (summer not required). Once enrolled in a developmental math course, students must make continuous progress each fall and spring semester in their developmental course until their required developmental courses have been completed for their declared program of study.

Continuous progress means that you must:

- Actively attend and submit assignments in your developmental courses.
- Complete developmental courses every semester with C grades or better.
- Register for the next course in your sequence the following semester (summer not required) until you have completed those courses required of you for your declared program of study.

If you do not make continuous progress, a registration hold will prevent you from registering for any other courses at WSU and can only be removed by the Student Success Center. You can contact them with any questions at (801) 626-6752, option 5.

Course Materials and Textbook

As part of MyLabsPlus, an online program, you will have access to the course text ebook. You may also buy a hard copy of the textbook if you wish: *Prealgebra,* by Blair, Tobey, Slater, 4th Ed. (ISBN 978-0-321-56793-2) or *Beginning and Intermediate Algebra, 4th Edition* (ISBN 978-0-321-44233-8) by Lial, Hornsby, & McGinnis. You will learn the course material by completing all homework, quizzes, tests, and final exam through MyLabsPlus. You must take notes on the general note-taking forms available in the bookstore or under the Doc Sharing tab in the course home page.

Course Requirements and Grades

Plan to spend a minimum of 9-12 hours per week in this course

WEEKLY REQUIREMENTS

1. Attendance: class (50 min), Hub (100 min); tracked from Monday morning to Sunday night
2. Complete study guide notes for each section while reading the text and/or watching video lectures.
3. Complete the module homework problems earning at least a 70%.
4. Take a module quiz or comprehensive test. Retake if you don't earn at least a 70%.
5. You must meet or exceed the calendar deadlines in order to finish the course this semester.

ATTENDANCE: 10% of grade**.**

Attend class 50 min per week and spend 100 min per week in a Hub (Lampros Hall at WSU Ogden or at WSU Davis). Contact your instructor if you must miss a class period. **NOTE: If you miss scheduled classes and Hub sessions, you may be in jeopardy of failing the course.**

Each week that you are working ahead of the schedule provided on the course calendar, you may request that your instructor waive the Hub attendance requirement for that week. Talk to your teacher during class to request a waiver of Hub attendance.

MODULE HOMEWORK: 30% of grade

You must complete each homework section with a 70% or better before you can move on to the next item. You may rework individual problems as necessary – only your best score is recorded.

MODULE QUIZZES: 30% of grade

Calculators are not allowed on quizzes or tests in this course. All quizzes must be taken in a HUB. Present study notes and picture ID to a HUB staff member for approval. To pass a quiz your score must be at least 70%. You can retake the entire quiz to improve your score and only the best score is used for your grade. Prior to a fourth attempt, you will need to work an additional homework assignment that is created from the concepts you missed. This additional assignment must be completed at an 85% level.

COMPREHENSIVE TESTS AND FINAL EXAM: 30% of grade

You must score at least a 70% on tests and the final exam. You must re-take the entire test or exam to improve your score and only the best score is used for your grade. Bring your picture ID.

GRADING SCALE (For students who finish the final exam with a 70% or better)

[93-100] A [90-93) A- [87-90) B+ [83-87) B [80-83) B- [75-80) C+ [70-75) C

If you do not finish the Final Exam by the end of the semester, your grade is assigned as follows:

If you complete at least 2 Comprehensive Tests, your grade will be a D

If you complete less than 2 Comprehensive Tests, your grade will be an E

If you do no work after the withdrawal deadline, your grade will be a UW

If your behavior violates University rules, you will be subject to appropriate sanctions, including reduced grades for course assignments. A first-time violation of testing protocols will result in a 10% reduction in your overall grade. A second violation will result in course failure.

*** If you do not finish the course in the first semester you register for it, you will be allowed to continue working on that course the next semester, starting where you left off. If this is the third semester you have registered for this course, or it has been more than 12 months since the first time you registered, you must begin at Module 1.

Computer-related Information

If you have trouble with your personal computer, run the browser check in MyLabsPlus and install any suggested updates.

Login at home: www.weber.edu. (Alternate login: www.devmath.weber.edu)

Use WSU username and password

Click on Student tab

In “My Courses” access your Math 0950, 0990, or 1010 course

HUB HOURS

All quizzes and tests must be started at least one hour before closing.

Monday – Thursday: 7:30 a.m. - 8:30 p.m.

Friday: 7:30 a.m. - 5:30 p.m.

Saturday: 8:30 a.m. - 5:30 p.m.

HUB LOCATIONS

Ogden Campus, Lampros Hall, Main floor

Davis Campus, Room 233

Note: You must sign in and sign out of the Tracker for your attendance to count.

HEADPHONES/ EARPLUGS

Headphones are available for checkout in the classrooms and the Hubs. You may bring your own headphones to watch the video lectures. Any standard headphone plug will work. Earplugs may be purchased for $0.25 at either Hub.

E-MAIL

Your Wildcat e-mail account is the official form of contact between you and your math instructor. Please check your Wildcat account daily.

Class and Hub Rules

- Students are in class and the Hub to work on math. Faculty and tutors are here to help students.
- Keep the atmosphere in class and the Hub positive, friendly, and respectful. If you fail to do so, you may be asked to leave.
- Food and capped drinks are allowed but must not be consumed near computer equipment. You will be responsible for any computer damage caused by your food or drinks.
- Please bring your Wildcard ID to every class and Hub session.
- Do not use a cell phone during class or Hub time. If you need to take an emergency call, please take it outside.
- For help, raise your "electronic" hand on Tracker.
- You may use your iPod or other listening devices when studying; please keep the volume low.

Testing Rules

- When testing you may only have a pen/pencil, and the testing scratch paper Hub personnel provide.
- Items not allowed while testing: hats, sunglasses, water bottles, food, drink, calculator, iPods, cell phones, or other electronic devices.
- Usage of outside calculators will not be allowed on quizzes or tests. The Windows scientific calculator may be enabled upon request for Math 1010 students only.
- All quizzes and tests must be started at least one hour before the Hub closes.
- A quiz or test will be immediately terminated if a student does any of the following: uses notes, books, calculators, iPods, cell phones, or other electronic devices, or leaves the computer.
- You must show your Wildcard ID or State ID and your completed study notes to Hub personnel before taking a quiz.

Frequently Asked Questions

What if I finish early?

If you finish this course early, you do not need to attend any more class or Hub sessions. Let your instructor know when you have passed the final exam with a 70% or higher.

I failed a quiz. What can I do?

The Study Plan zeroes in on areas you have not mastered, so use it to practice before you take the quiz again. Go to any Hub or ask your instructor for help in using the Study Plan. You may retake a quiz or test. Only your best score is used to calculate your final grade